1230

LOGIC ANALYZER

WORKBOOK

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PRODUCT GROUP 43

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Tektronix®
COMMITTED TO EXCELLENCE

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HOW TO USE THIS WORKBOOK

This workbook is divided into three sections. The first section, *Learning the 1230*, discusses the 1230 mainframe, its controls and connectors, and its menu-driven operating system. Read this section before attempting to do the examples in the other sections.

The second section, *Examples Requiring 16 or Fewer Channels*, consists of hands-on examples that show you how the 1230 can be used to solve problems. These examples are progressive so work through them in order. Each example assumes you have mastered the techniques used in previous examples. All of the examples in this section require only the standard 1230 configuration: 16 channels with one P6443 probe and three lead sets.

The third section, *Examples Requiring More Than 16 Channels*, provides more examples to expand your knowledge of the 1230. These examples, however, require a 1230 equipped with 1230E1 expander cards and additional probes and lead sets.

RECOMMENDED DOCUMENTATION. When using this workbook, it is recommended that you also have access to the *1230 Operator's Reference Guide*, part number 070-6880-00.

REQUIRED EQUIPMENT. To work the examples in Section 2 of this workbook, you will need:

1 1230 Logic Analyzer

1 1230 Operator's Reference Guide (070-6880-00)

1 Power Cord

1 Test Circuit (671-0049-00)

1 P6443 probe

3 lead sets (any combination of 174-1264-00, 174-1265-00, or 174-1266-00)

1 8" test lead

2 single-sided grabber tips (013-0217-00)

To work the exampes in Section 3, you will need:
(note: some examples require less equipment)

1 1230 Logic Analyzer

1 1230 Operator's Reference Guide (070-6880-00)

1 Power Cord

3 Test Circuits (671-0049-00)

4 P6443 probes

12 lead sets (any combination of 174-1264-00, 174-1265-00, or 174-1266-00)

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SECTION ONE

LEARNING THE 1230 LOGIC ANALYZER

This section introduces you to the TEKTRONIX 1230 Logic Analyzer. It contains descriptions of the 1230's capabilities, connectors, controls, and menu structure. Read through this section completely before moving on to the other sections.

Product Overview

The TEKTRONIX 1230 Logic Analyzer is a modular, general-purpose test and measurement tool useful in the design, manufacture, and service of digital devices. The 1230 mainframe is lightweight, rugged, portable, and quiet. As a modular instrument, it can be configured to meet your specific application. It supports hardware debugging, software analysis, microprocessor disassembly, and hardware/software integration.

The 1230 mainframe provides 16 channels at 25 MHz (synchronous and asynchronous), 8 channels at 50 MHz (asynchronous), or 4 channels at 100 MHz (asynchronous). Up to three 1230E1 Expander Cards may be installed in the mainframe, increasing the number of channels to 64 (16 channels/expander card).

An additional timebase is provided by each installed 1230E1 Expander Card. This allows you to simultaneously collect data from different parts of the system under test (SUT) with different sampling rates. For example, a 64-channel 1230 can disassemble an 8-bit microprocessor and acquire eight channels of 100 MHz timing data at the same time.

Optional RS-232 and GPIB interfaces allow you to use the 1230 as part of an integrated system. Data can be transferred between the 1230 and a remote host. The 1230 can also be remotely controlled.

The 1230 is easy to use. Operation is controlled through selections you make in screen menus. A menu bar at the bottom of each screen describes how to do most functions. The 1230 also provides on-line notes if you need additional information on any menu. The rest of this section describes the 1230 mainframe and shows how to access and use the menus.

Mainframe Controls and Connectors

Figures 1-1 and 1-2 illustrate and define most of the 1230 mainframe. Use these figures to locate specific controls and connectors on your own 1230. For a more detailed description of the mainframe, refer to the *1230 Operator's Manual.*

Specific use of the mainframe's controls are described in more detail throughout this workbook as needed.

Front-Panel Controls and Connectors

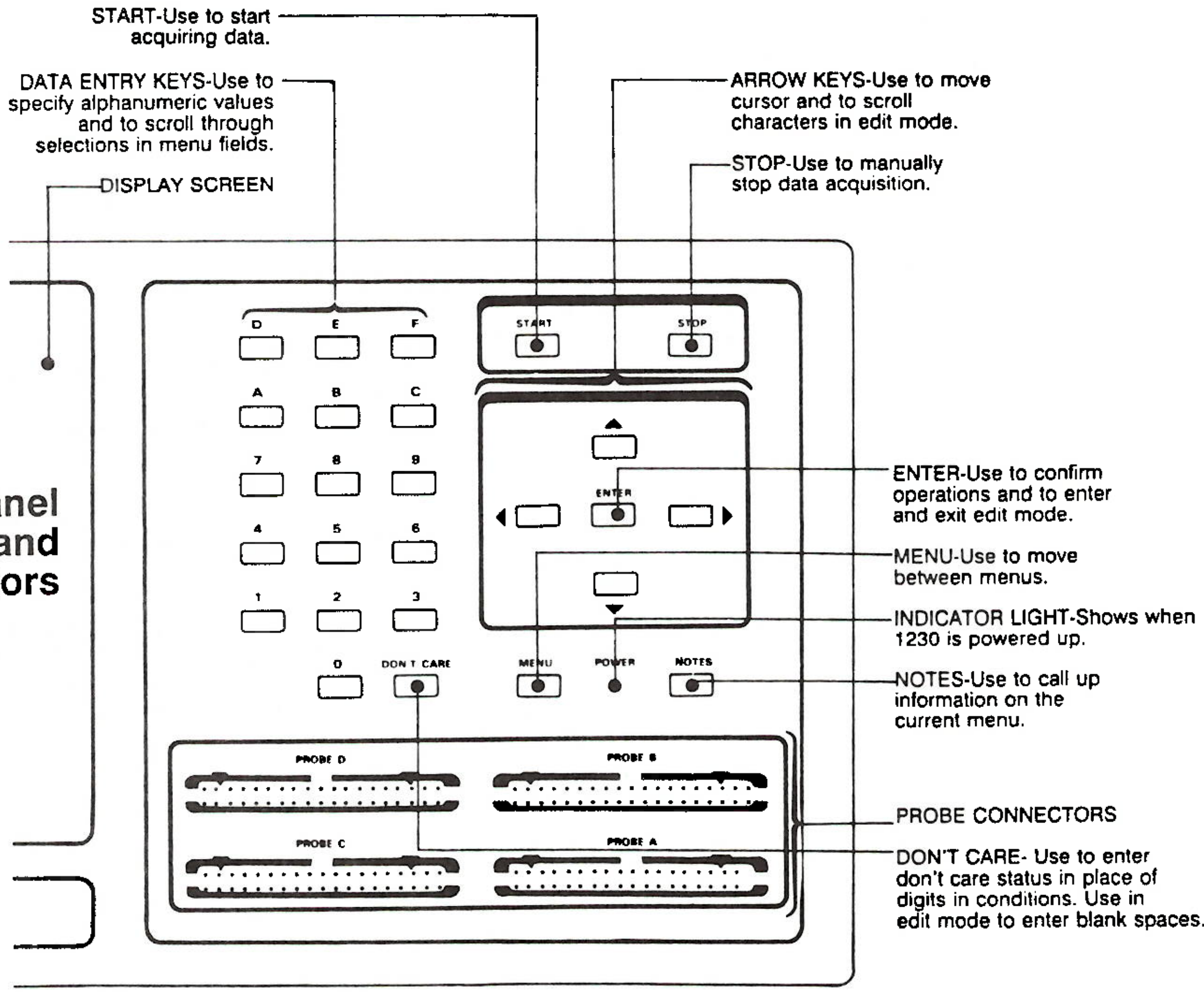

Figure 1-1. 1230 Front Panel.

Rear-Panel Controls and Connectors

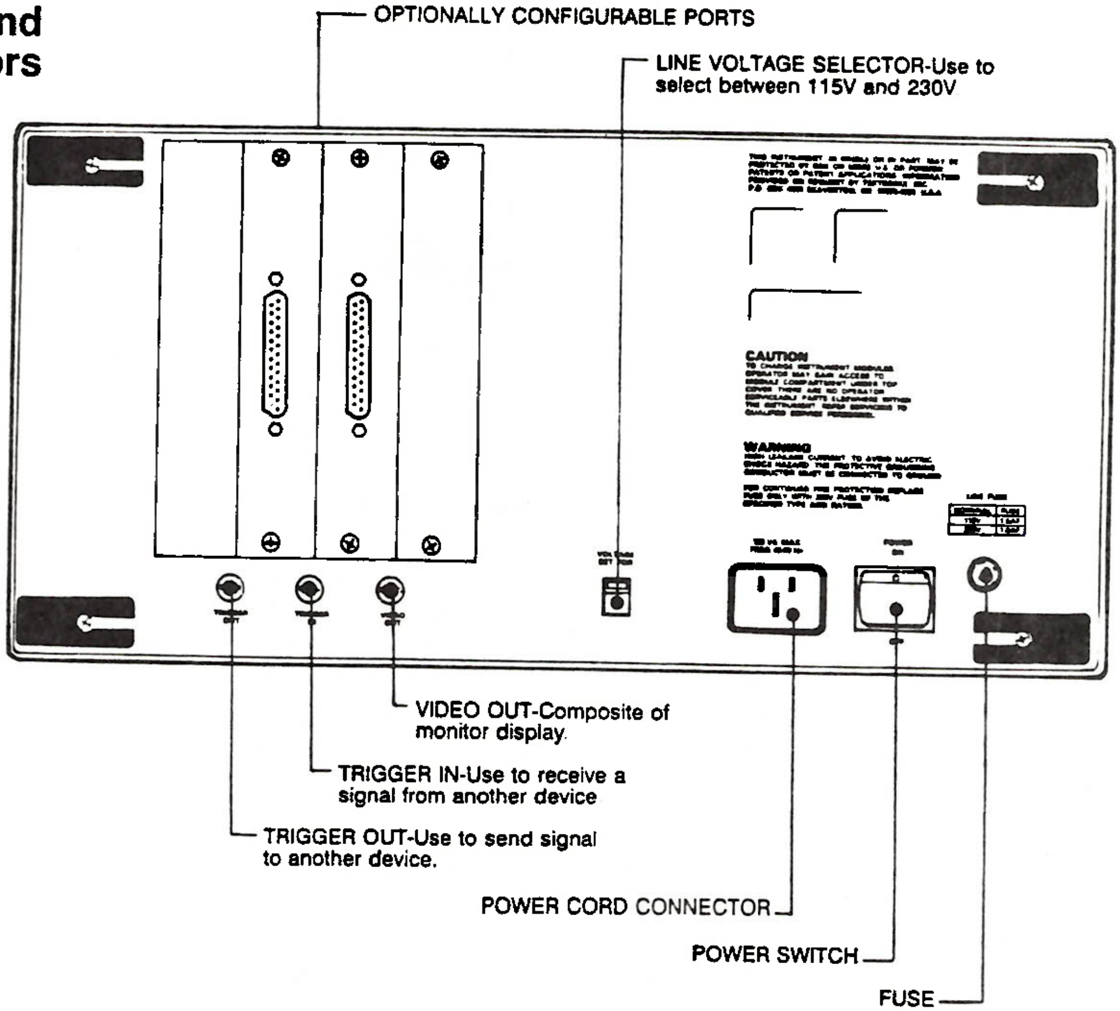

Figure 1-2. 1230 Rear Panel.

Connecting Probes and Lead Sets

CONNECTING PROBES TO THE 1230 MAINFRAME. The 1230 probe cable connectors plug into pin connectors located on the instrument's front panel (see Figure 1-3). Notches on the connectors insure that the connectors are aligned correctly. To connect the probe cable to the 1230, power down both the SUT and the 1230, then press the cable's female connector firmly onto the front-panel connector pins.

CAUTION

Never connect a powered-up circuit to a powered-down 1230. Doing so could damage your probe. Before connecting a probe to the 1230, make sure both the SUT and the 1230 are powered down. Then, after connecting the probes, power up the 1230 before powering up the SUT.

To acquire data, probe slot A must always have a probe plugged into it. If you are using more than one probe, you don't have to connect others in any particular order. However, because 1230E1 cards must be installed in order, you will find it less confusing to plug the second probe into slot B, the third into slot C, and so on.

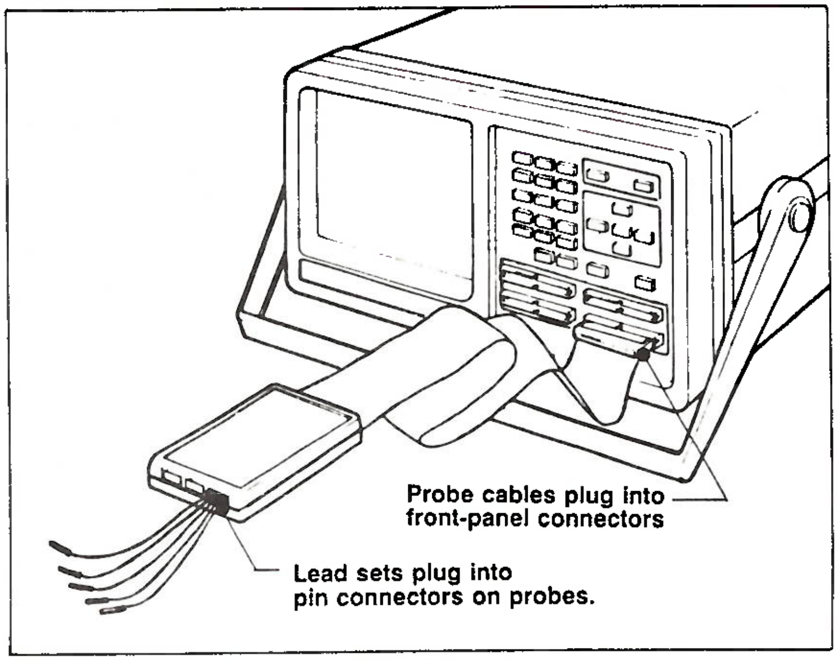

Figure 1-3. Probe and Lead Set Connections. To acquire data, a probe must always be plugged into slot A.

CONNECTING LEAD SETS TO THE PROBES. Each probe has pin connectors for three lead sets. You only need to connect lead sets to the pins on which you intend to acquire data. To connect lead sets to probes, firmly press the lead set's female connector onto the probe's pin connector. Notches on the top of the lead sets ensure correct orientation. The label on top of the probe identifies the leads by color, making it easier for you to figure out which flying lead is associated with which probe input. To make identifying leads easier, it is a good idea to use a lead sets with different colored tips. Lead sets come in three different colors: black, white, and red.

CONNECTING LEADS TO THE SYSTEM UNDER TEST. There are a number of different ways to connect leads to your system. For the examples in this workbook, you only need to know two. One way is to plug the end of the flying lead onto the test card's pins. The other way is to plug the end of the flying lead onto a grabber-tip pin and attach the grabber tip to the test card's pins (see Figure 1-4).

NOTE

Always connect the probe ground leads to a ground on your SUT.

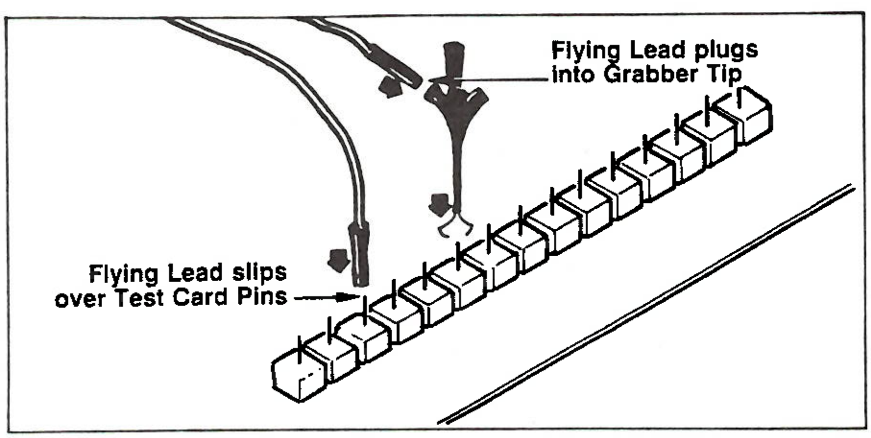

Figure 1-4. Connecting Leads to the Test Card.

Mainframe Power Up

Once the probes and lead sets have been connected, perform the following steps to power up the 1230 mainframe:

1. Check the Line Voltage Selector Switch on the rear panel to make sure it is set for the voltage in your area. Selections are 115 V and 230 V. The rear panel is shown in Figure 1-2.
2. Plug the 1230 power cord into the power cord connector on the rear panel. Then plug it into a proper power receptacle.
3. Flip on the rear-panel power switch.

At power up, the 1230 displays the Initialization Menu shown in Figure 1-7. This menu tells you the instrument configuration (how many channels are available), the current date and time, which setup is currently loaded, and what version of firmware is installed. Press NOTES to display information about operating the 1230.

Installing Expander Cards

The 1230 Master Analyzer Board, always resident in the 1230, provides you with 16 data acquisition channels. To increase the number of channels, you must install 1230E1 Expander Cards. Each card provides you with an additional 16 data channels. Up to three expander cards may be installed to give you a total of 64 data acquisition channels. Each of the examples in Section 3 requires a 1230 configured with expander cards.

To install 1230E1 cards, you will need a magnetic-tip #1 POZIDRIV screwdriver. The following steps explain how to install expander cards in your 1230 mainframe:

1. Make sure power to the 1230 is off and the power cord is disconnected.
2. Make sure that the 1230 is protected from static.

CAUTION

Static discharge can damage any semiconductor in this instrument. Damage to electrical components may not be immediately apparent. Take standard anti-static precautions.

3. Remove the 1230 top cover by removing the four Phillips-head screws on the cover, two on each side. Figure 1-5 shows the 1230 top cover and the circuit-board cover.
4. Lift the cover and set it aside.
5. Refer to Figure 1-5. Remove the three screws on the right side of the metal plate that covers the circuit boards, then loosen the three captive screws on the left side of the plate.
6. Lift off the metal plate and set it aside.
7. Firmly, but gently, plug the expansion card (or cards) into the appropriate card slot. Plug the first card into the slot on the right, the second card in the middle slot, and the third card in the slot on the left. Make sure each card is well-seated as shown in Figure 1-6.
8. Connect the cards to the probe-interconnect cables as follows. Figure 1-6 shows the probe-interconnect cables and cards.
   - Connect the right-expansion card to probe B's connector.
   - Connect the middle-expansion card to probe C's connector.
   - Connect the left-expansion card, the one closest to the Controller board, to probe D's connector.
9. Replace the circuit-board cover and screws.
10. Replace the 1230 top cover and screws.

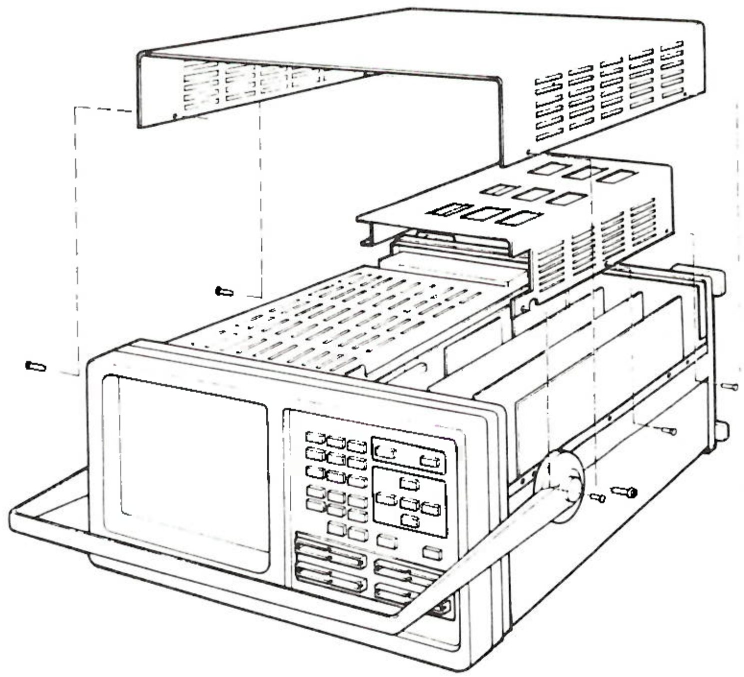

Figure 1-5. Disassembling the 1230 mainframe to install 1230E1 Expander Cards.

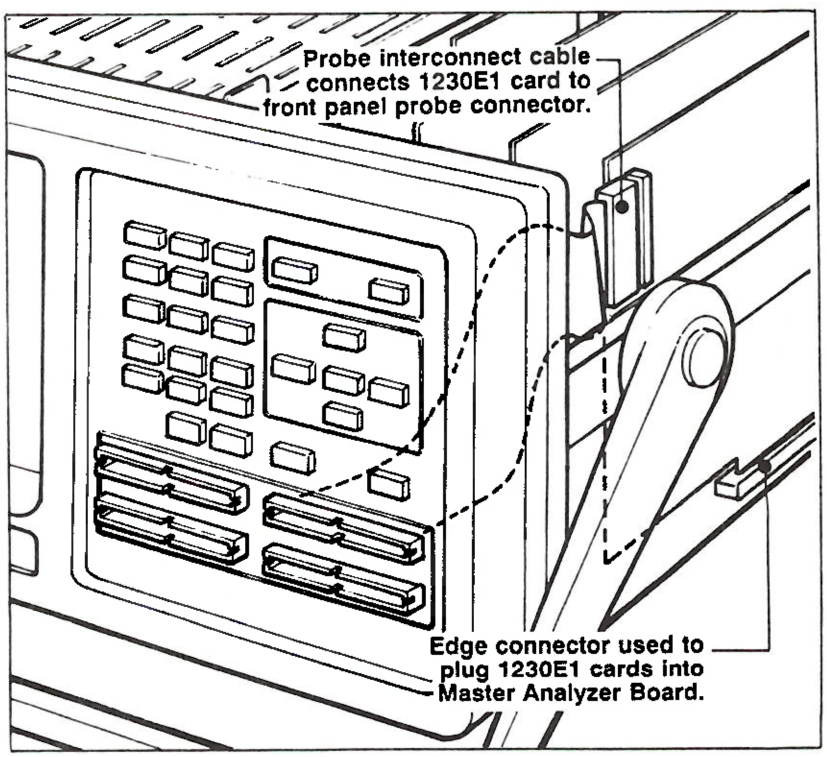

Figure 1-6. Installing 1230E1 Expander Cards. Connect the probe cables to the expansion cards as shown here. Interconnect cable A should already be attached to the Master Analyzer board.

MENU OVERVIEW

Menu Descriptions

The operation of the 1230 is controlled by selections you make in menus displayed on the screen. When you first power up the 1230, the menu selections are the same as they were when the instrument was last powered down. If you want to restore the default menu configuration, simultaneously press NOTES and ENTER (to reset the 1230), followed by D (for Default).

The 1230 menus are divided into three groups:

Setup Menus – Control the acquisition of data.

Data Menus – Control how acquired data is displayed.

Utility Menus – Control the storage of setups and system settings such as screen intensity and the current date and time. If you have options such as RS-232 or GPIB interfaces installed, they will also be controlled from this group of menus.

This section describes the 1230's menus in general terms only. Specific menu operations are discussed as needed in the examples later in this workbook. For a detailed description of the menus, refer to the *1230 Operator's Manual.*

ACCESSING MENUS. When you first power up the 1230, the Initialization Menu shown in Figure 1-7 is displayed. To access this menu again, you will have to reset the 1230 either by turning it off and on again or by simultaneously pressing NOTES and ENTER. To call up any other menu, press MENU to call up the Main Menu shown in Figure 1-8. Then, press the number corresponding to the menu you want. For example, to call up the Channel Grouping Menu, press MENU followed by 1.

TUE, MAR 08, 1988 10 48 -DEFAULT

Tektronix 1230/16 Channel Logic Analyzer, V3.00
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Use the NOTES key whenever information is needed,
or consult the Operator's Manual.

X represents DON'T CARE condition.

Press MENU to continue

Figure 1-7. Initialization Menu. Appears when the 1230 is first powered up or reset. It gives you the current date and time, the name of the current setup, the number of channels your 1230 is configured for, and the version of firmware installed.

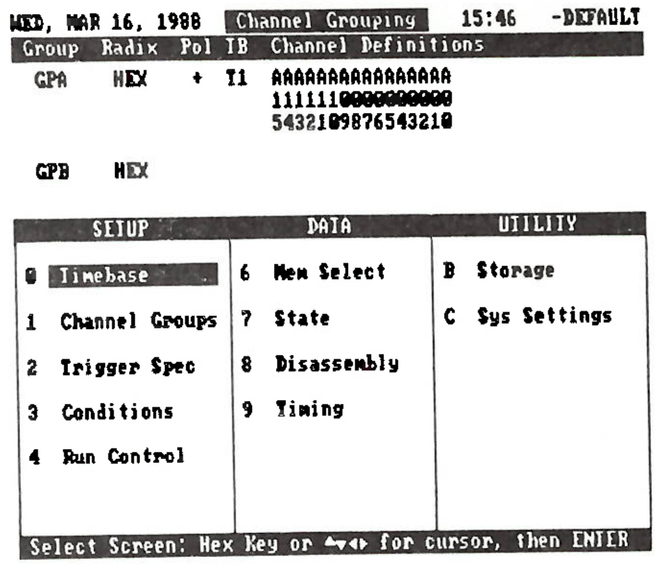

Figure 1-8. Main Menu. Gives you access to the other 1230 menus. To call up a menu, press the number associated with it.

ON-LINE INFORMATION. To help you in setting up menus, the 1230 provides two types of on-line information: notes and menu bars. Pressing NOTES in any menu calls up a screen full of text describing the menu and its functions. A highlighted menu bar at the bottom of each menu briefly describes the keystrokes required to make changes to the menu. Some menus have more than one menu bar of information. To cycle through the menu bars, press F.

PROMPTS AND ERRORS. There are some types of menu changes you can make that will affect selections in other menus. For example, turning on glitches in the Timebase Menu reduces the number of channels available in the Channel Grouping Menu. When you make a selection that will affect other menus, a box will appear on the screen prompting you to confirm the change.

If you try perform an operation that conflicts with the 1230's configuration, a box containing an error message will appear on the screen. For example, you will get an error message if you try to load a stored setup that does not match the current probe configuration.

MENU FIELDS AND CURSOR MOVEMENT. Use the arrow keys on the front panel to move the cursor from field to field. The cursor position is shown in reverse video. To change a field, the cursor must be positioned on it. The arrow keys also move the data cursor in data display menus.

There are two types of changeable fields in 1230 menus: select fields and fill-in fields. Select fields only allow you to choose from pre-defined selections. You cycle selections through select fields by placing the cursor on it and pressing specific front-panel keys. The menu bar at the bottom of the screen will tell you which keys change the values in the field.

Fill-in fields allow you to enter character strings. Some of these fields allow you to enter characters as soon as the cursor is placed on the field. Others require you to press ENTER to enter edit mode before characters may be entered. This latter type are usually fields, such as channel group names, in which you might want to enter characters not found on the keypad. In these cases, pressing ENTER puts you in edit mode. The up and down arrow keys can then be used to cycle characters through the field. Pressing ENTER again will take you out of edit mode.

ACQUIRING DATA. To acquire data, first connect the 1230 to your system with probes and lead sets as shown earlier in this section. Then, set up the menus in the Setup Menu group. When you have finished setting up the menus, press START to begin the acquisition. The examples in subsequent sections of this workbook describe data acquisition in more detail. They tell you how connection probes and which menu selections to choose in order to acquire data that is useful for specific types of applications.

Setup Menus

The menus in the Setup Menu group work together to control how data is acquired and stored. There are four menus in this group:

TIMEBASE MENU. The Timebase Menu allows you to control the acquisition clock and how probes are linked (if more than one probe is available). Two clock formats are available: synchronous and asynchronous. If you select Async as the clock format, you may also select a clock rate.

Turn glitches on if you want to trigger on a glitch. Otherwise, leave them turned off because turning them on reduces the number of channels available for data acquisition.

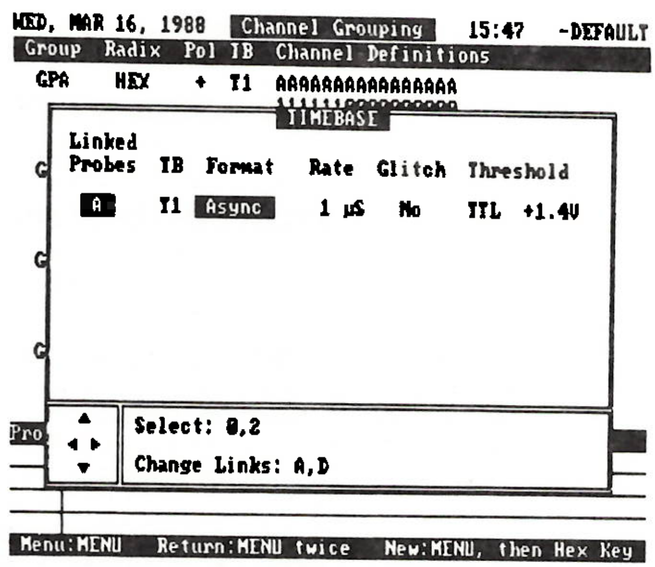

Figure 1-9. Timebase Menu.

CHANNEL GROUPING MENU. The Channel Grouping Menu allows you to group channels together. When channels are grouped, their data is displayed together. Channel groups are also used to define trigger conditions. You can only group channels from different probes together if the same timebase has been selected for them in the Timebase Menu.

The Channel Grouping Menu also allows you to select the radix in which trigger conditions for each group are defined and the polarity (positive or negative logic) used when acquiring data.

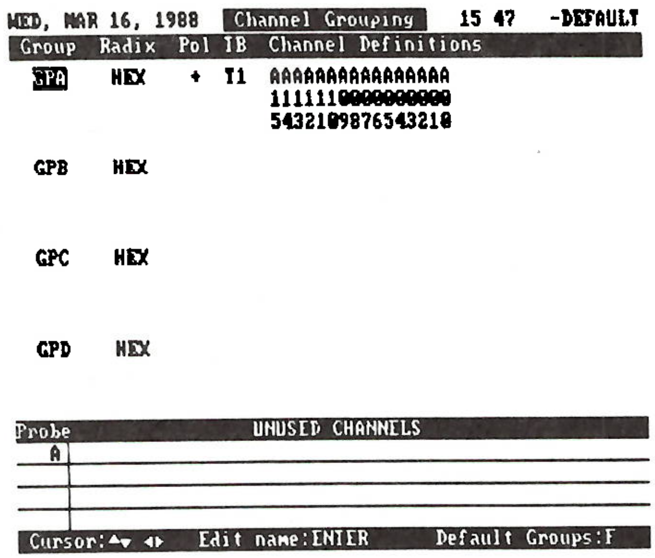

Figure 1-10. Channel Grouping Menu.

TRIGGER SPEC MENU. The Trigger Spec Menu allows you to specify up to 14 levels of trigger statements. These statements control the sequence of events the 1230 looks for before triggering, the action it performs when it finds a specified event, and what data gets stored. These statements resemble the condition statements found in most computer programming languages.

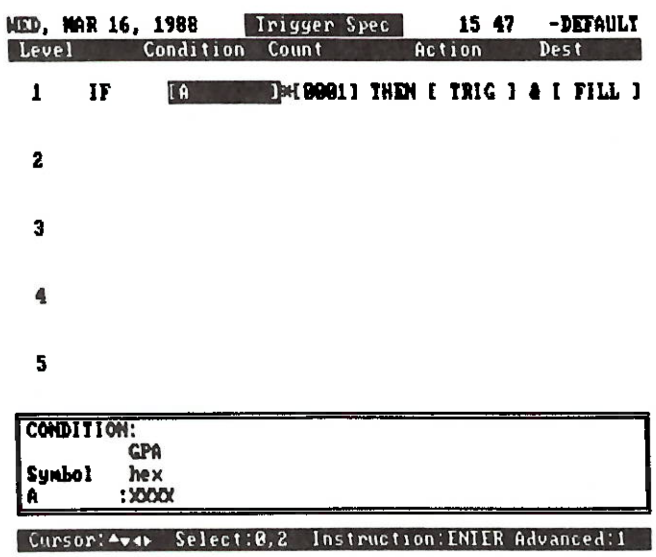

Figure 1-11. Trigger Spec Menu.

CONDITIONS MENU. The Conditions Menu lets you define conditions (combinations of high and low signals) for the 1230 to use in its trigger seach. These conditions are selectable in the Trigger Spec Menu. If glitches are turned on, they may be included in condition definitions. Conditions are also used to determine which channels are compared to each other when you compare memories.

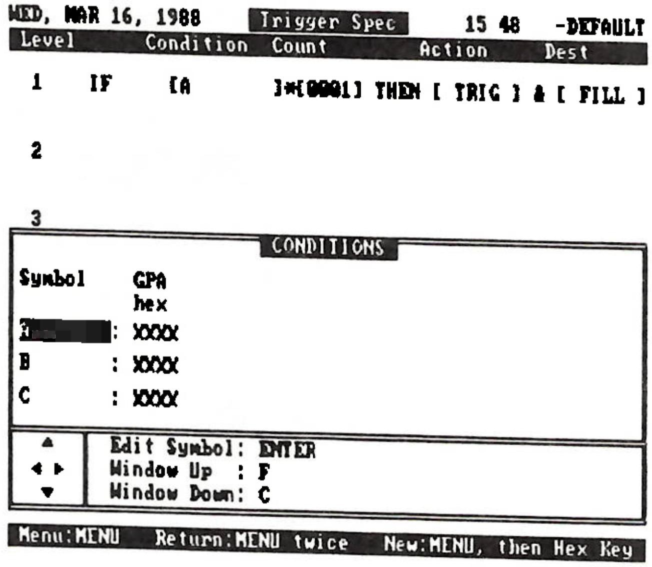

Figure 1-12. Conditions Menu.

RUN CONTROL MENU. The Run Control Menu is divided into two parts. The upper part allows you to choose which of the 1230's four memories the acquisition will be stored in, which format will be used to display data when the acquisition is complete, which memory location the trigger event is stored at, and how much data is acquired before the 1230 begins looking for the trigger. The lower part of the menu allows you to set parameters for comparing one memory to another.

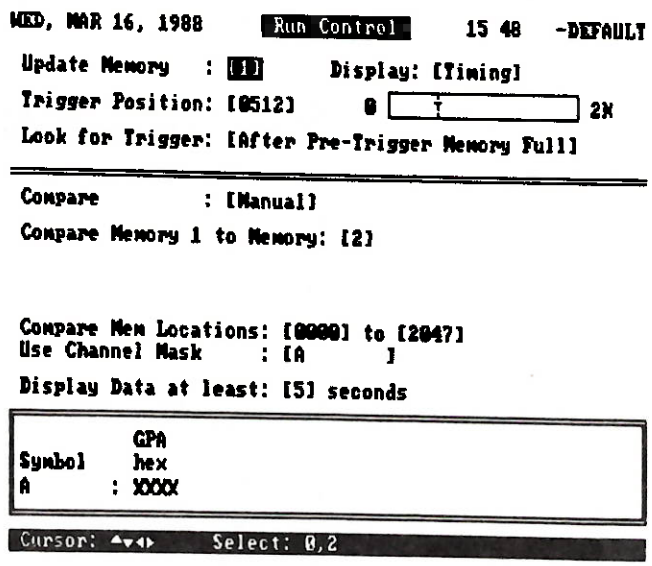

Figure 1-13. Run Control Menu.

Data Menus

The menus in the Data Menu group are used to display acquired data.

MEMORY SELECT MENU. The Memory Select Menu gives you information about the data stored in each of the 1230's four memories. It lists the date and time the data was acquired, plus all the selections made in the Timebase Menu for that acquisition. Selecting a memory in this menu allows you to display it if the current instrument configuration is the same as it was when the data was acquired.

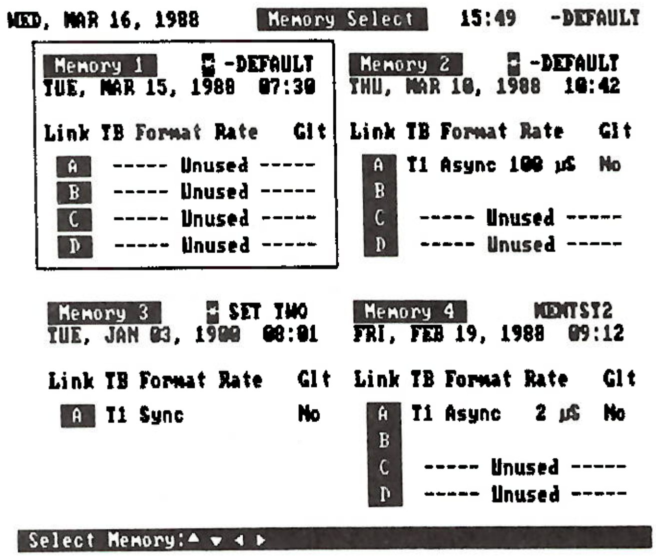

Figure 1-14. Memory Select Menu.

STATE MENU. The State Menu displays data in a state table format. For each memory location, it gives you a numerical representation of the logic state of each channel group. You may change the radix used to display the data, turn off the display of a particular group, or search for a specific event. The State Menu also shows you the trigger location and the results from comparing one memory to another.

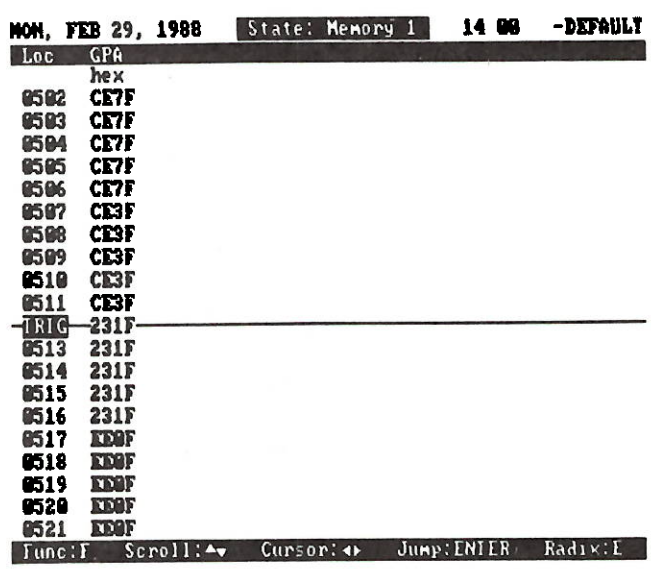

Figure 1-15. State Menu.

DISASSEMBLY MENU. This menu is only available if you are using an optional disassembly probe to acquire data. Since this menu is not used in any of this workbook's examples, it is not shown.

TIMING MENU. The Timing Menu displays data from each channel as a timing trace or digital waveform. You may rename the trace labels and change the order in which they are displayed. By setting a reference point for the data cursor, you can measure the time elapsed between specific data samples.

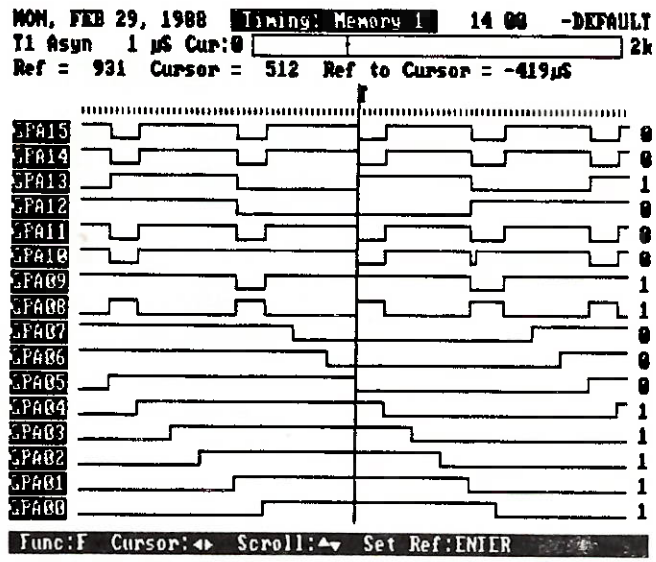

Figure 1-16. Timing Menu.

UTILITY MENUS

The menus in the Utility Menu group allow you to store setups and set some system parameters. If your 1230 has any options installed, they will be controlled from menus in this group.

STORAGE MENU. The Storage Menu allows to store setups (the selections made in setup menus) for use at a later time. To reload a setup, the system configuration must by the same as when the setup was created. Setups may be protected to prevent them from being accidentally overwritten.

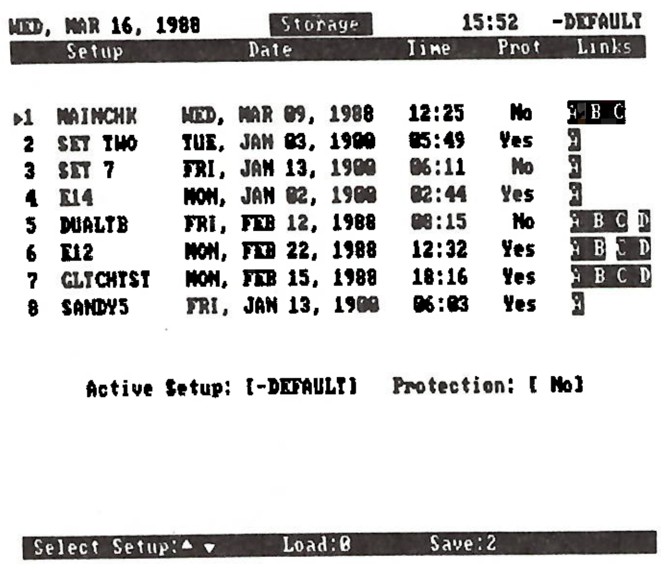

Figure 1-17. Storage Menu.

SYSTEM SETTINGS MENU. The System Settings Menu allows you to set the 1230 clock's date and time. It also lets you vary the brightness of the screen and turn the screensaver on or off. If you turn on the screensaver, the screen will automatically darken if no keys are pressed for a long time. This prevents screen burn-in and will prolong the life of your 1230's CRT.

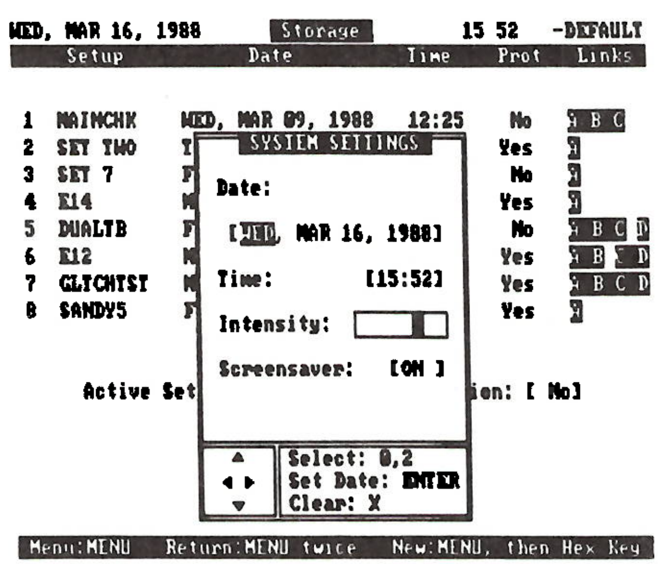

Figure 1-18. System Settings Menu.

TYPES OF DISPLAYS

Data Display Overview

Once the logic analzyer has acquired data from the circuit under test, you can choose to display the data several different ways. The two most common data formats are *timing* format and *state* format. In general, both types of displays give you the same information, but depending on your application, one type of display may be much easier to read and interpret.

TIMING FORMAT DISPLAY. Data displayed in timing format looks much like an oscilloscope screen. Refer to Figure 1-19. Each data channel is represented by a horizontal trace showing high and low voltage states. Timing format is most often used to measure small time differences between signals changing states.

Timing diagrams display idealized waveforms that represent the logic state of each data channel at various points in time. The waveform is idealized because it only tells you if the data channel voltage was above or below a pre-set threshold voltage at the time the sample was taken. It is also idealized because the logic analzyer only samples the data channel's voltage at specified times (the sample interval) and hence can only show you timing differences greater than or equal to the sampling rate of the analzyer.

When you view a timing diagram, you need to consider the threshold voltage, the sample rate, and the trigger position. The threshold voltage (usually 1.40 V for TTL logic) tells you the meaning of high and low timing traces. The sample rate tells you the resolution of the timing display; faster sample rates allow the logic analzyer to more accurately represent the circuit under test.

The trigger position determines how much data you will be able to see before and after the trigger event; if the trigger word is positioned at the beginning of memory, you will only be able to see events that occurred after the trigger word; if you position the trigger word in the middle of memory, you will be able to see some events that occurred both before and after the trigger event.

The Timing Menu provides a number of tools to help you evaluate acquired data. The channel name for each trace is listed at the left side of the screen. Additional channel traces can be viewed by scrolling the display up or down using the arrow keys. The data event that caused the logic analzyer to trigger (trigger word) is marked with a vertical cursor and a T. This cursor can be moved to other data samples by using the arrow keys. Any cursor position can be set as a reference point. Then when the cursor is moved, the distance in time between the two samples is displayed in a field at the top of the menu.

A horizontal bar-graphic (the memory indicator) at the top of the menu shows you which portion of acquisition memory is currently being displayed, and a small T in this window shows where the trigger word appears. You can use the functions available in the menu bar at the bottom of the menu to change the scale of the timing traces; a very fine scale will allow you to see differences between traces as small as one sample, while a very coarse scale will allow you to see much more data at one time. There are also functions available that allow you to change the ordering of traces on the display and to change the rate of data scrolling.

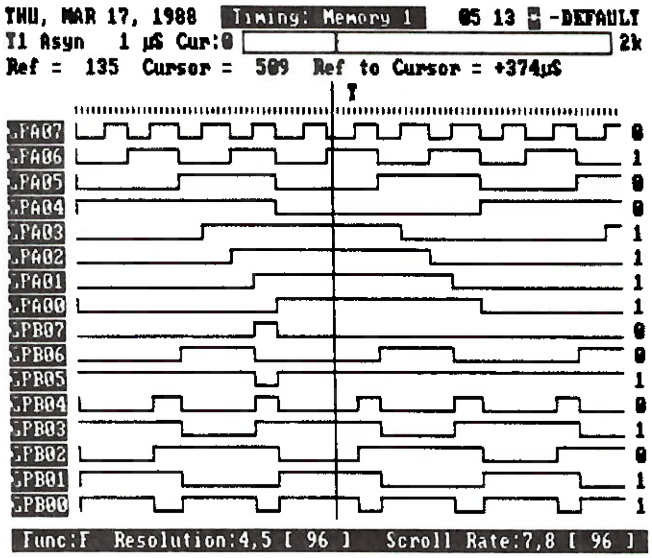

Figure 1-19. Timing Diagram. Data displayed in timing format is much like an oscilloscope screen. Each data channel is represented by a horizontal trace that shows you its voltage state (above or below the threshold voltage) at various points in time. Comparing two or more traces can often tell you if there is a broken connection or a internal race condition in your circuit.

STATE FORMAT DISPLAY. State format displays data as numeric entries in a table. Refer to Figure 1-20. Each column represents a data channel (or channel group), and each row represents the data acquired for all channels at one point in time. You can look up the data value for any particular channel at a particular point in time by reading accross the top of the display until you find the right channel group and then reading down the rows until you find the desired time (memory location).

The data values in a state table represent the same information shown in a timing diagram, but instead of representing the voltage state of each channel as a waveform, the state table represents the voltage by using an alphanumeric character. Typically, channels measured above the threshold are represented by a numeric 1, and channels below the threshold are represented as a 0; this is called a binary (base 2) display. When many data channels are represented in the same menu, it is often more convenient to display the data values in either octal (base 8) or hexadecimal (base 16) format. You can change the display format from one numbering system (radix) to another at any time; choose the one most convenient to your application. Tables 1-1 and 1-2 show the octal and hexadecimal radix equivalents of binary numbers.

Table 1-1
BINARY TO OCTAL RADIX EQUIVALENTS

Binary	Octal	Binary	Octal
000	0	100	4
001	1	101	5
010	2	110	6
011	3	111	7

Table 1-2
BINARY TO HEXADECIMAL EQUIVALENTS

Binary	Hex	Binary	Hex
0000	0	1000	8
0001	1	1001	9
0010	2	1010	A
0011	3	1011	B
0100	4	1100	C
0101	5	1101	D
0110	6	1110	E
0111	7	1111	F

As with the timing diagram, when you view a state table, you need to consider the threshold voltage, the sample rate, and the trigger position. The threshold voltage tells you the meaning of high and low data values. The sample rate tells you the resolution of the data; faster sample rates allow the logic analzyer to more accurately represent the circuit under test. There will be times, however, when you are less concerned with resolution and place more value on the number of system-under-test cycles you can capture.

The trigger position determines how much data you will be able to see before and after the trigger event; if the trigger word is positioned at the beginning of memory, you will only be able to see events that occurred after the trigger word; if you position the trigger word in the middle of memory, you will be able to see some events that occurred both before and after the trigger event.

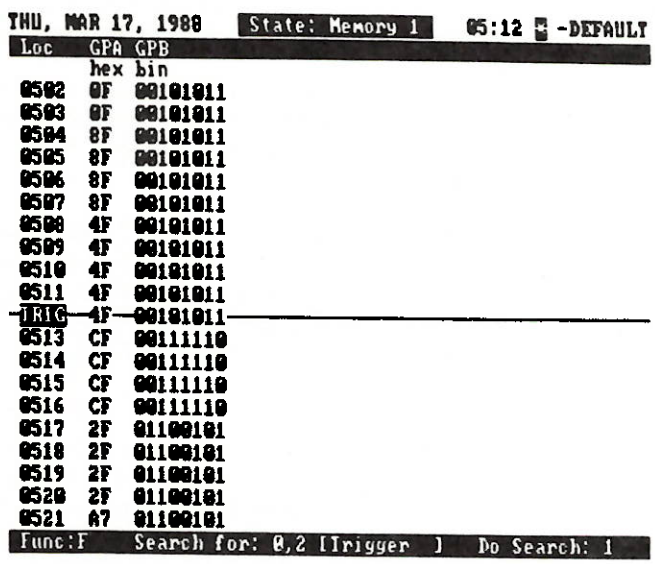

Figure 1-20. State Table. Data displayed in state format appears in a list where each column represents a channel (or channel group) and each row represents a different data sample; the earliest data samples appear at the top of the list. Data samples can be displayed in binary, octal, or hexadecimal notation depending on whether you need to interpret the bits individually or whether it is easier to read them in alphanumeric form.

The State Menu display provides a number of tools to help you evaluate acquired data. The location number for each data sample is displayed on the left side of the screen; the first (oldest) samples have low numbers and are displayed at the top of the screen. The trigger position is marked with in inverse video. A variety of functions accessible via the menu bar at the bottom of the menu allow you to change the display radix of channel groups and search for specific data words.

State tables are often the most convenient way of showing data when you are debugging software problems. Software problems frequently require you to examine the states of address bus, data bus, and control lines simultaneously; if you tried to examine that number of timing traces simulateously, you would soon dispair of ever making sense out of your data. For the same reason, even a state table showing that number of data states in binary format quickly becomes unusable, so the most common state tables display data in hexadecimal.

Microprocessor disassembly listings are a specialized type of state tables; instead of just listing the voltage levels in binary, octal, or hexadeciamal radixes, the logic analyzer translates known patterns to their assembly language equivalents and displays the mnemonics on the screen. This can be of great help in evaluating what instruction the microprocessor was attempting to execute, but you should remember that the mnemonic display is fundamentally no different than other state table displays. (Mnemonic disassembly requires an optional, microprocessor-specific data probe.)

TEST CARD DESCRIPTION

Test Card Used To Generate Data for Examples

The examples in this workbook use the Test Circuit (Tektronix p/n 671-0049-00) to simulate a system under test (SUT). The test card provides digital data patterns which the 1230 can acquire. It generates 16 logic states which repeat over and over. Figure A1 on the pull-out page at the rear of this workbook shows these states in timing diagram format. Note that channels nine and twelve generate glitches.

The test card provides 23 data lines, 3 clock lines, 2 ground lines, and a glitch line. Each of these lines is connected to a labeled square pin on the circuit board, making it easy for you to connect data acquisition leads to them. Figure A2 shows the test card schematic.

The test card's power source is a 3 volt lithium battery (Tektronix p/n 146-0063-00). The battery is connected to the circuit via a slide switch. All of the cards ICs require very little power to operate. However, if the ICs are driving relatively low impedance loads, the power consumption goes up substantially. The battery will last for many hours if only high-impedance loads (or no loads) are being driven.

NOTE

When it is not in use, be sure to switch off the test card and disconnect it from the 1230. Even if the test card is turned off, the battery will continue to drain if it is left connected to a powered-up 1230.

Figure A-3 on the pull-out page shows the test card's component layout.

TEST CARD BATTERY CHECK

Use a digital volt meter (DVM) to check the voltage from the top of the battery to a GND square pin. Voltage values should be between 2.6 volts and 3.5 volts. If lower then 2.6 volts, exchange the battery.

Lithium batteries require special considerations for handling and disposal.

WARNING

Improper handling may cause fire, explosion, or severe burns. Do not re-charge, crush, disassemble, heat the battery above 100 degrees Celsius, incinerate, or expose contents of the battery to water. To avoid personal injury, observe the proper procedures for handling and disposal of lithium batteries given below.

Dispose of batteries in accordance with local, state, and national regulations. Typically, small quantities of batteries (less than 20) can be safely disposed of with ordinary garbage in a sanitary landfill. Larger quantities must be sent by surface transport to a Hazardous Waste Disposal Facility. The batteries should be individually packaged to prevent shorting and packed in a sturdy container that is clearly labeled "Lithium Batteries -- DO NOT OPEN."

SECTION TWO
EXAMPLES REQUIRING 16 OR FEWER CHANNELS

This section provides hands-on examples designed to familiarize you with the 1230's operation and to give you an idea of the broad range of applications in which it can be used. These examples are progressive, each building the skills acquired in the previous examples. You should start at the beginning and work through the examples consecutively.

This section assumes you have read Section 1 of this workbook and are familiar with how to connect data acquisition probes and power up the logic analyzer.

REQUIRED EQUIPMENT. To work the examples in this section, you will need:

1 1230 Logic Analyzer

1 *Operator's Reference Guide* (070-6880-00) or
1230 Operator's Manual (070-6878-00)

1 Power Cord

1 Test Circuit (671-0049-00)

1 P6443 probe

3 lead sets (any combination of 174-1264-00, 174-1265-00, or 174-1266-00)

1 8" test lead (196-3222-00)

2 single-sided grabber tips (013-0217-00)

EXAMPLE ONE

Acquiring Data Asynchronously

OVERVIEW. Logic analyzers acquire data samples based on transitions of a clock signal. That is, a data sample is acquired every time a clock pulse occurs. There are two basic types of clocking: asynchronous and synchronous. When data is acquired asynchronously, the clock used is a signal generated internally by the logic analyzer. This allows you to select the clock, and thus the sampling, rate. When data is acquired synchronously, the clock is a signal received from the system under test (SUT).

In this first example, we will acquire data asynchronously from the 671-0049-00 Test Circuit that came with your 1230. Initially, we will use the 1230's default setup. Then, we will make a couple of additional acquisitions with slightly different clock rates so you can see the importance of choosing the right clock rate.

After completing this example, you should know:

- how to connect probes to a SUT
- what the 1230's default setup consists of and how to load it
- how to make single data acquisitions
- how to change the asynchronous sampling rate
- how to look at data in timing diagram format and how to change the display resolution
- how to switch to state table format to search for the trigger location

PROBE CONNECTIONS. With both the 1230 and the test card powered down, connect Probe A to the 1230 (instructions for making the physical connections are given in Section 1 of this workbook). Connect the probe leads to the test card pins as shown in Table 2-1. Leads not listed in the table should be left unconnected.

Table 2-1
PROBE TO TEST CARD CONNECTIONS

Input	Pin
D0	BIT23
D1	BIT22
D2	BIT21
D3	BIT20
D4	BIT19
D5	BIT18
D6	BIT17
D7	BIT16
GND	GND
D8	BIT15
D9	BIT13
D10	BIT12
D11	BIT11
D12	BIT3
D13	BIT2
D14	BIT1
D15	BIT0
GND	GND

Once all the connections have been made, power on the 1230. Then, turn on the test card.

CAUTION

Never connect a powered-up circuit to a powered-down 1230. Doing so could damage the logic analyzer. When you must power down the test setup, turn off the test circuit before the logic analyzer.

1A. The Default Setup: Trigger on Anything

INSTRUMENT SETUP. The first acquisition will be made using the 1230's default setup. When the 1230 is powered up, it retains the setup that was previously in effect. The best way to make sure you have the default setup is to re-load it from where it is stored in nonvolatile RAM. To do this, simultaneously press NOTES and ENTER (to reboot the instrument). Then, press D (for Default).

If the default setup is loaded, the upper-right corner of the screen will say -DEFAULT. Before actually making an acquisition, let's take a look at the default setup. To access the various menus, press MENU to call the Main Menu which contains a list of the available menus (an overview of all the menus is contained in Section 1 of this workbook), Then, press the number corresponding to the menu you want. As you get to know the numbers associated with the menus, you can press the combination without waiting for the Main Menu. For example, pressing MENU followed by 0 calls the Timebase Menu.

The menus in the Setup Menu Group are as described in the following paragraphs.

Timebase Menu – Note that the clocking format is Async with a rate of 1us. Glitch detection is turned off and the threshold voltage is set for TTL components (see Figure 2-1).

Channel Grouping Menu – All the channels from Probe A (A15-A00) are grouped together with a HEX radix (see Figure 2-2). The radix you select in this menu will determine which radix you must use to define conditions for the channel group.

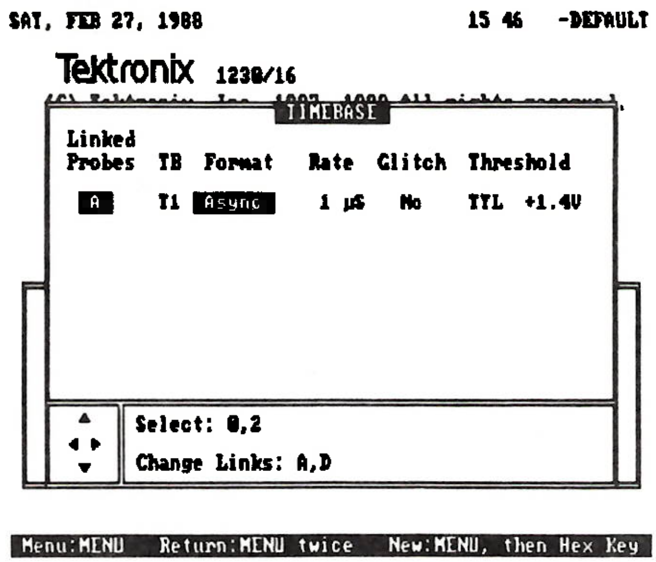

Figure 2-1. Default Timebase.

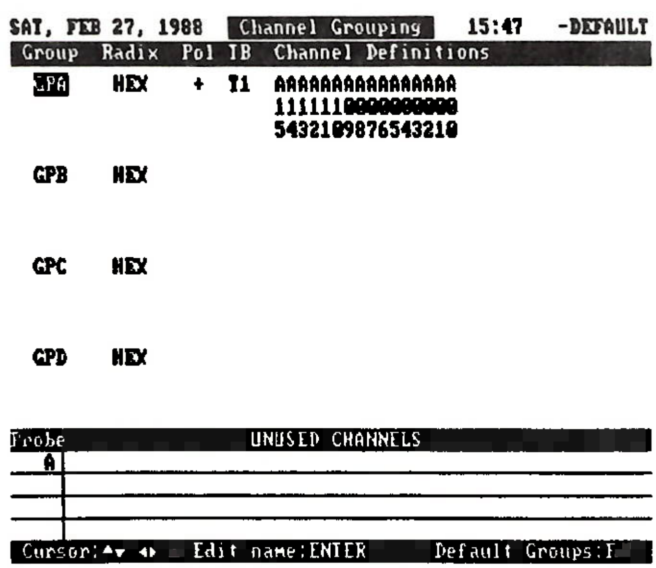

Figure 2-2. Default Channel Grouping.

Conditions Menu – Twenty-four conditions are defined. In each of them, every channel is marked with don't cares (symbolized by X). When a channel is given a don't care, the 1230 ignores its value (see Figure 2-3).

Trigger Spec Menu – The logic analyzer will trigger and fill memory when condition A occurs (see Figure 2-4). Recall from the Conditions Menu that all condition A's channels are set to Don't Care (X). Since no specific channel group value is being looked for, the 1230 will trigger on the first clock pulse after the trigger is enabled (see *Run Control Menu*, following).

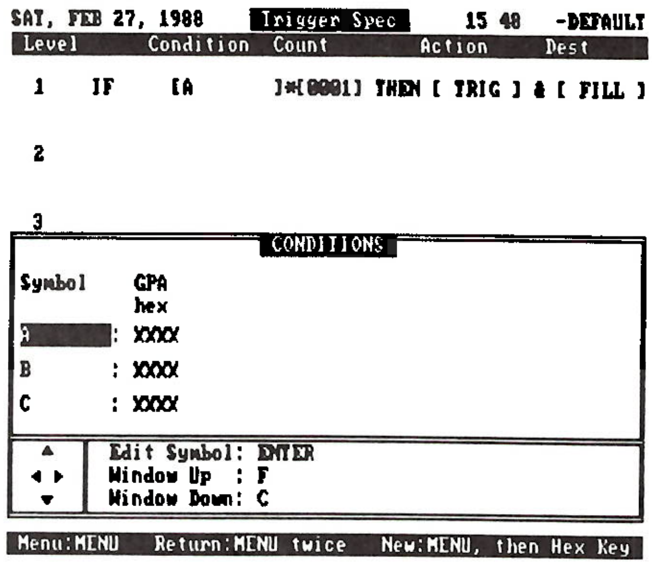

Figure 2-3. Default Conditions.

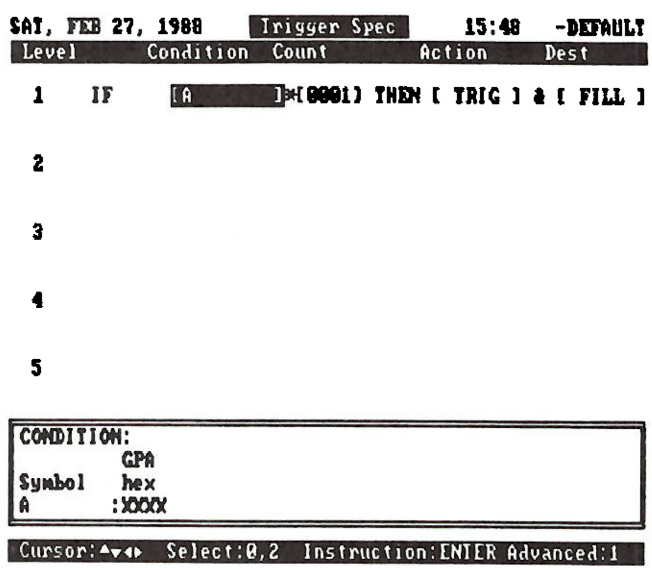

Figure 2-4. Default Trigger Specification.

Run Control Menu – The acquisition will be stored in Memory 1 (the 1230 provides four, 2K-deep memories). Timing is the default display type; however, after the acquisition has been made, you may choose to display it in either a timing diagram or state table.

Note that the trigger position is at location 512 in memory and that the trigger is enabled after the pre-trigger memory is full (see Figure 2-5). This means that the 1230 will not start looking for condition A (our trigger condition) until after enough data has been acquired to fill 511 memory locations.

The lower section of the Run Control Menu controls data comparison, a feature we will not use in this example.

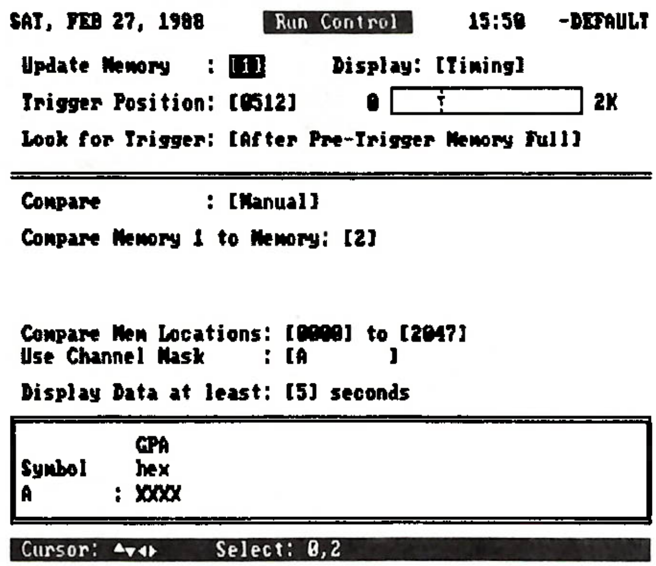

Figure 2-5. Default Run Control.

ACQUISITION. To begin, press START. The 1230 begins acquiring data on the first clock pulse after START is pressed. Once the pre-trigger memory is full, the 1230 starts looking for the trigger. Since the trigger condition in this example is all don't cares (basically, trigger on anything), the 1230 will trigger on the first data sample after it starts looking for the trigger. The trigger will be positioned at memory location 512. When enough data has been acquired to fill Memory 1, the acquisition stops and data is processed for display.

DATA DISPLAY. Once the acquisition is complete, data is displayed in the Timing Menu (see Figure 2-6). If you compare the digitized waveforms on the screen with the same traces in the tests card's timing diagram (Figure A-1 on the pull-out page), they should be very similar. Pay particular attention to the "walking bits" on channels GPA07 through GPA00. We will be looking at these same channels in part B of this example and it will help if you remember the stair-step pattern of their transitions.

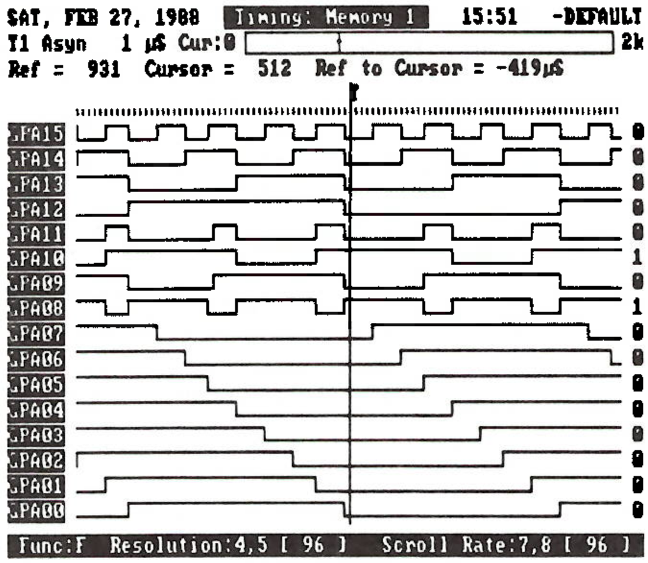

Figure 2-6. Timing Menu shows data from Example 1.

The menu bar at the bottom of the screen lists functions available in this menu. Pressing F changes the menu bar so that it lists additional functions. The following steps will take you through the some of the more common things you might want to do in the Timing Menu.

1. MOVING THE DATA CURSOR. Press the right and left arrow keys a few times (the menu bar at the bottom of the screen will remind you which keys perform which functions). Notice that this moves the data cursor to the left or right one graticule mark at a time.

   Each mark represents one clock pulse so that you are moving the cursor by one data sample at a time. The actual number of the cursor position is shown in the Cursor field above the traces. This number changes every time you change the cursor position.

   Another way of locating the cursor position is to look at the memory domain indicator. This bar represents the whole active memory. A vertical line within the bar shows the relative location of the cursor. A small T shows where the trigger location is.

2. SCROLLING THE DISPLAY. Press the up and down arrow keys a few times. This scrolls the display a whole screen at a time. The cursor stays in the same position on the screen, but the data moves by as many locations as are selected in the menu bar's Resolution field.

3. CHANGING THE RESOLUTION. In the Timing Menu, the resolution is the number of data samples (or clock cycles) displayed on the screen at one time. Press F (for Function) until one of the functions listed in the menu bar is Resolution.

   Press 5 to change the resolution of the screen. At a resolution of 2048, several of the timing traces are so condensed that they appear as solid bars.

   Press 4 until the resolution is 6. At this point so little data is on the screen at any time that it becomes difficult to see relations between the signal transitions. Picking the proper resolution can make viewing data much easier. Press 5 until the resolution is once again at 96. Notice that the resolution setting in the menu bar changed as you pressed 4 and 5.

4. MEASURING THE TIME BETWEEN SAMPLES. In addition to the data cursor, the 1230 provides a reference cursor to allow you to measure the time elapsed between two data samples. The reference cursor is marked by a dashed vertical line and its position is shown in the Ref field near the top of the menu. Press ENTER. This sets the reference cursor at the same location as the data cursor. Note that the Ref to Cursor field is set to zero. Press the right arrow key to move the cursor away from the reference position marked by the dashed line. See how the Ref to Cursor field changes.

5. LOCATING THE TRIGGER. The trigger position is marked with a T right above the traces. There are two ways to locate the trigger. One way is to hold down the arrow keys until the cursor scrolls to it. You can tell how far there is to go by looking at the memory domain indicator bar. The other way (which is often faster) is to locate the trigger in the State Table Menu first. To do this, press MENU followed by 7 to move to the State Menu (see Figure 2-7). Press F until one of the items in the menu bar is Search for. The item in brackets should be Trigger (otherwise, press 0 or 2 until Trigger comes up). Press 1 to start the search. The cursor will move to the trigger location. Press MENU, followed by 9, to move back to the Timing Menu. The cursor will still be on the trigger position.

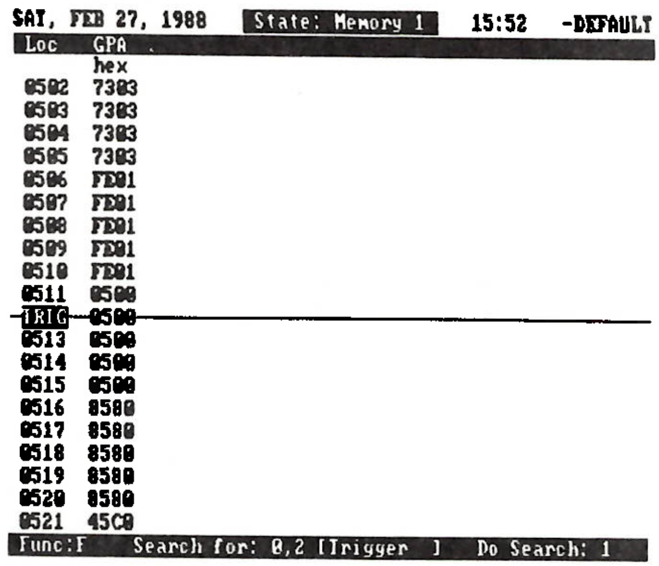

Figure 2-7. State Menu shows data from Example 1.

1B. Varying the Clock Rate

For this part of the example we want to look at the effects of changing the asynchronous clock rate. The acquisition setup will be the same as was used in part A with the following exception: In the Timebase Menu, change the clock rate to 20 μs. To do this, enter the Timebase Menu and place the cursor on the Rate field. Then, press 0 or 2 until 20 μs is selected.

Press START to acquire new data. The acquisition will be the same as in part A, except that the sampling rate will be different.

Note that the data display is too crowded to be easily viewed. Press 4 until the resolution is such that you can see when transitions on different channels occurred in relation to each other.

Look at channels GPA07 through GPA00. It appears that many of the transitions on these channels occurred at the same time. However, if you recall the "walking bit" pattern they formed in part A, you know this isn't actually the case. What has happened is that you have acquired data with a sampling rate that is too slow. Each data sample is like a photograph of the circuit's state at a given point in time. If you don't take a picture often enough, you miss a lot of states.

To ensure that every high and low transition is captured, you want your sampling rate to be at least twice as fast as the fastest frequency of data being sampled. For better signal resolution, the sample clock should be ten or more times faster than the data rate. For example, the oscillation frequency of the test card is approximately 200 kHz. So, when you acquired a data sample at 1 μ in part A, your sample clock was about five times faster than the test card's frequency (200 kHz × 5 = 1 MHz or 1 μs).

Next we'll make an acquisition with a clock rate that is too fast. Change the rate in the Timebase Menu to 80 nS. Then, press START to make the acquisition.

Note how far apart transitions are on the screen. It's very hard to see relationships between events on various channels if you can't see them on the screen at the same time. In this case, you can change the resolution to 2048 and be able to see the pattern on channels GPA07 through GPA00. However, if you sample at a fast rate, you fill memory more quickly, thus reducing the total time over which you can aquire and store data. This loss can be important if the event you wish to observe does not occur frequently.

EXAMPLE TWO

Synchronous Triggering on a Specific Event

OVERVIEW. Digital systems can generate millions of states in just a few seconds. Since analyzers cannot store all this data (and you wouldn't want to sort through it even if they could), they have the ability to recognize and trigger on a specific data pattern. This lets you select your observation window so that only data you are interested in gets stored. A trigger might be a rising or falling edge on a single input, but a more useful trigger is often a combination of highs and lows across many parallel channels.

In Example 1, we acquired data asynchonously with a don't care trigger condition. In this example, we will make a synchronous acquisition using a signal from the SUT as the acquisition clock. We will also choose a specific combination of high and low signals (we call this an event or word) to be the trigger condition. Except for adding a clock line, the connections to the SUT will be the same as they were in Example 1; however, we will change the channel grouping to make the data acquired more meaningful.

This type of circuit measurement has a great many different applications in digital logic systems. For example, suppose you wanted to look at the activity on a data bus immediately after a write enable has occurred. To do this, you would group all the control lines into one channel group and all the data bus lines into another. Then, you would set up the logic analyzer to trigger on the write enable event. This would allow you to quickly locate the data you were interested in.

While only one clock signal from the SUT is being used in this example, you may have noticed that the probe has inputs for four clock signals: two high and two low. High clock inputs cause data to be acquired when the signal goes from a logic low to a logic high. We call this acquiring on a rising edge (by the way, this is what the 1230 does when acquiring asynchronously). Conversely, the clock low inputs cause data to be acquired on a falling edge (a transition from logic high to logic low). If you connect more than one clock to a probe, they are ORed together. That is, data is acquired whenever an appropriate transition occurs on any clock line.

After completing this example, you should know how to:

- group channels
- define trigger conditions
- save an instrument setup and protect it
- make a synchronous data acquisition
- use the major features associated with the State Table Menu

PROBE CONNECTIONS. The connections used in this example are the same as those used in Example 1, except that you need to connect a probe clock line since this is a synchronous acquisition. To do this, perform the following:

1. Turn off the test card.
2. Twist the red CLOCK HIGH lead and the orange GND lead around each other as shown in Figure 2-8. Twisting the leads together reduces signal noise. It is only absolutely necessary at clock rates faster than 15 MHz; however, it's a good habit to get into.
3. Connect a CLK HIGH lead to the CLK1 pin on the test card and the ground to a pin labeled GND.
4. Making sure the 1230 is already powered up, turn on the test card.

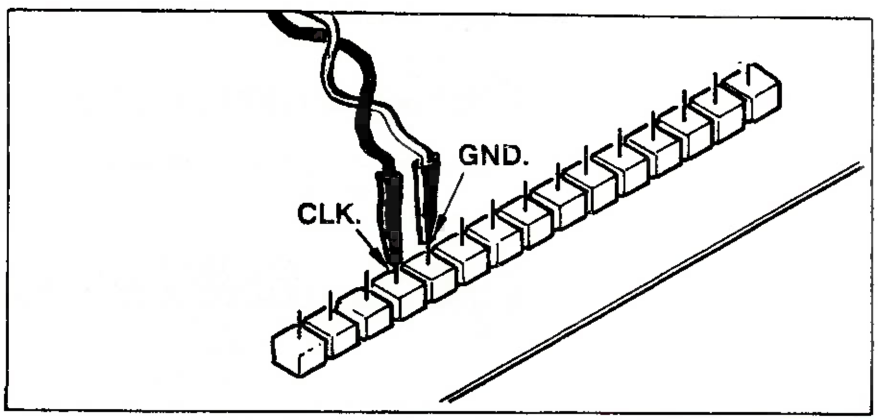

Figure 2-8. Connecting Clock and Ground Inputs.

INSTRUMENT SETUP. Starting with the default setup used in Example 1, make the following setup menu changes. If you aren't certain you have the default setup, re-load it by simultaneously pressing NOTES and ENTER (to reboot the 1230), followed by D (for Default).

NOTE

When a setup has been modified since being loaded, its name in the upper-right corner on the screen is preceded by an asterisk.

Timebase Menu – Change the timebase to Sync. Glitches should still be turned off and the threshold voltage set to TTL (see Figure 2-9).

Channel Grouping Menu – Change the names of two channel groups (see Figure 2-10). Call one of the groups TWD (for trigger word) and assign channels A7 through A0 to it. Call the next group DAT (for data) and assign it channels A15 through A08.

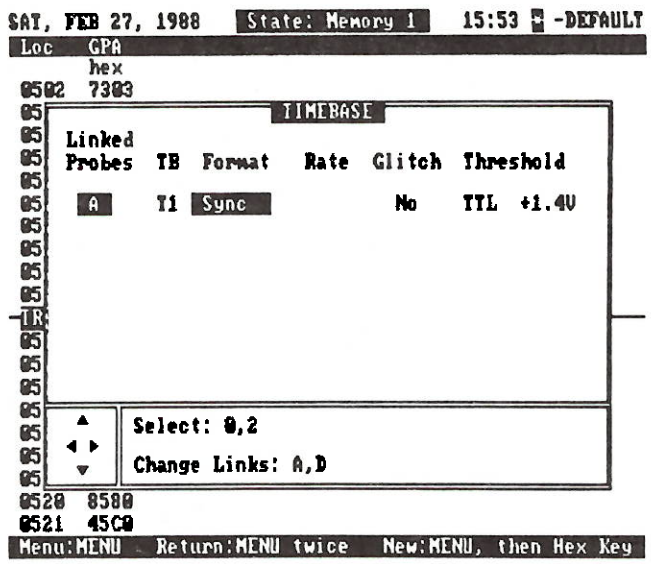

Figure 2-9. Timebase Menu showing Synchronous Clock Format.

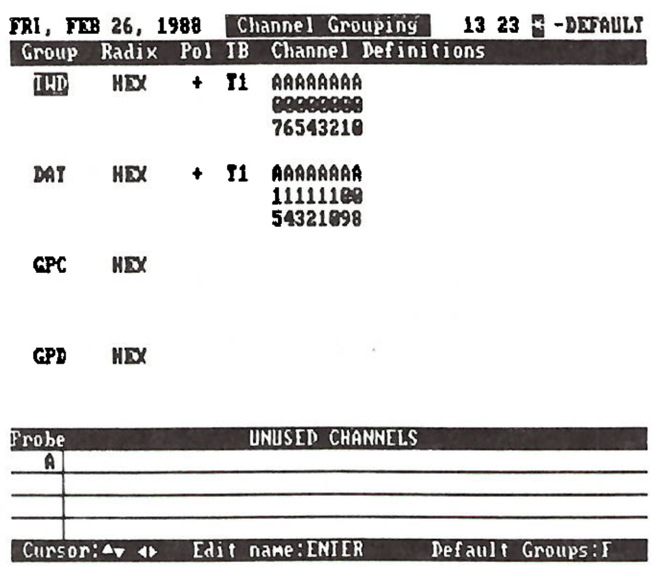

Figure 2-10. Channel Grouping for Example 2.

To change the name of a channel group, place the cursor on the name and press ENTER. This puts the 1230 in editor mode. Use the up and down arrow keys to scroll through the characters. Use the left and right arrow keys to move the cursor to a different character position within the group name. Press ENTER when you have finished changing the name.

To delete a channel from a group, place the cursor on it and press 0. The menu bar at the bottom on the screen will remind you which keys to press if you forget. Note that as you delete each channel it gets listed as an unused channel at the bottom of the screen. This allows you to quickly see which channels are not currently being used.

To add a channel to a group, place the cursor where you want it and key in the channel number. If you are adding channels in order (as we are in this case), you can avoid having to enter each channel number by pressing E. This causes the next unused channel to be added to the group.

NOTE

A channel can only be assigned to one channel group at a time. To move a channel from one group to another, you must first delete it. Then, it will be listed as an unused channel and can be added to a group.

Conditions Menu – Change one of the default condition names to EVENT (see Figure 2-11). Set the value of the TWD group to 1F*hex* (if you look at the test card's timing diagram, you can see that this state should occur). Leave the rest of the channel groups all don't cares. The names of conditions are changed as described previously for changing channel group names. Change another of the default condition names to MASK. Leave all the channel group values Don't Cares. This group will be used in Example 3.

Trigger Spec Menu – Check to make sure the 1230 is set to trigger and fill memory when the event defined as EVENT (that is, 1F*hex*) occurs once (see Figure 2-12).

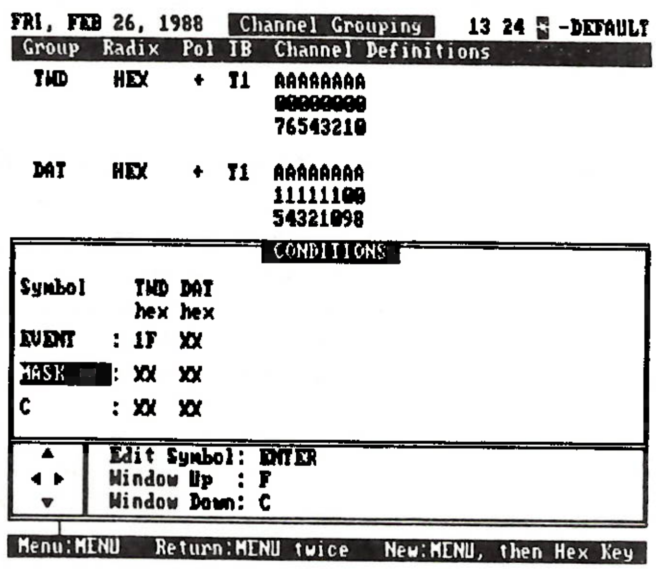

Figure 2-11. Conditions for Example 2.

```
SAT, FEB 27, 1988   Trigger Spec      16:07 -DEFAULT
Level     Condition  Count        Action      Dest

1   IF      [EVENT    ]=[0001] THEN [ TRIG ] & [ FILL ]

2

3

4

5

CONDITION:
           TWD DAT
Symbol     hex hex
EVENT      :1F  XX

Cursor:▲▼◄►  Select:0,2  Instruction:ENTER Advanced:1
```

Figure 2-12. Trigger Spec for Example 2.

Run Control Menu — In the Update Memory field, select 1. You want to keep track of which of the four memories you are using because it will be saved for use as a reference memory in later examples (see Figure 2-13).

Change the Display field to State. The 1230 should be set to look for the trigger After Pre-Trigger Memory Full.

```
FRI, FEB 26, 1988     Run Control     13:25 -DEFAULT
Update Memory    : [1]        Display: [State]
Trigger Position: [0512]      0 [   T         ] 2K
Look for Trigger: [After Pre-Trigger Memory Full]

Compare          : [Manual]
Compare Memory 1 to Memory: [2]


Compare Mem Locations: [0000] to [2047]
Use Channel Mask      : [EVENT    ]
Display Data at least: [5] seconds

           TWD DAT
Symbol     hex hex
EVENT    : 1F  XX

Cursor: ▲▼◄►        Select: 0,2
```

Figure 2-13. Run Control for Example 2.

MON, JAN 09, 1989 — Storage — 03 50 — SET TWO

	Setup	Date	Time	Prot	Links
1	MICROCHK	TUE, FEB 16, 1988	11:09	Yes	A B C D
▸2	SET TWO	TUE, JAN 03, 1989	05:49	Yes	A
3	MEMTST2	THU, FEB 18, 1988	14:48	Yes	A B C D
4	E14	MON, JAN 02, 1989	02:44	Yes	A
5	DUALTB	FRI, FEB 12, 1988	08:15	No	A B C D
6	E12	MON, FEB 22, 1988	12:32	Yes	A B C D
7	GLTCHTST	MON, FEB 15, 1988	10:16	Yes	A B C D
8	SANDY	MON, JAN 09, 1989	03:36	No	A

Active Setup: [SET TWO] Protection: [Yes]

Select Setup:▲ ▼ Load:0 Save:2

Figure 2-14. Storage Menu shows Setup Two saved.

Storage Menu – Since this same instrument setup will be needed for several other examples, you may want to save it now. This will keep you from having to set it up again. The Storage Menu is shown in Figure 2-14. To save the setup, do the following:

1. Place the cursor in the Active Setup field at the bottom of the list.
2. Press ENTER to enter editor mode. Enter a unique name for the setup such as SET TWO for the setup used in Example 2. Use the up and down arrow keys to scroll characters through the field and the left and right arrow keys to move the cursor within the field. Pressing X will give you a blank space in the name. Press ENTER when you have finished changing the setup name.
3. Place the cursor on the Protection field and press 0 to change the selection to Yes. This will prevent any modification to the stored setup.
4. Press the up and down arrow keys until the arrow on the screen points to the setup you want to replace with the current one. Figure 2-14 shows it saved in position 2.
5. Press 2 to save the setup. Then, press ENTER to confirm that you really want to save it.

ACQUISITION. Once you have made the required changes to the instrument setup, press START to begin acquiring data. The 1230 acquires data until the pre-fill memory

NOTE

If the Acquisition Status Menu flashes a Slow Clock message, check your probe connections, especially the GND and CLOCK leads. The white lead in the clock lead set is a qualifier, not a ground. If it is connected to ground, the 1230 will not see the clock pulses from your SUT.

DATA DISPLAY. In Example 1, we looked at data in a timing diagram format. Each channel was viewed individually as a waveform over time. In this example, we are looking at data in state table format (see Figure 2-15). Instead of seeing a waveform for each channel, what we see are numerical representations of channel group values, one set of values for each memory location. By default the values are displayed in a hexadecimal radix.

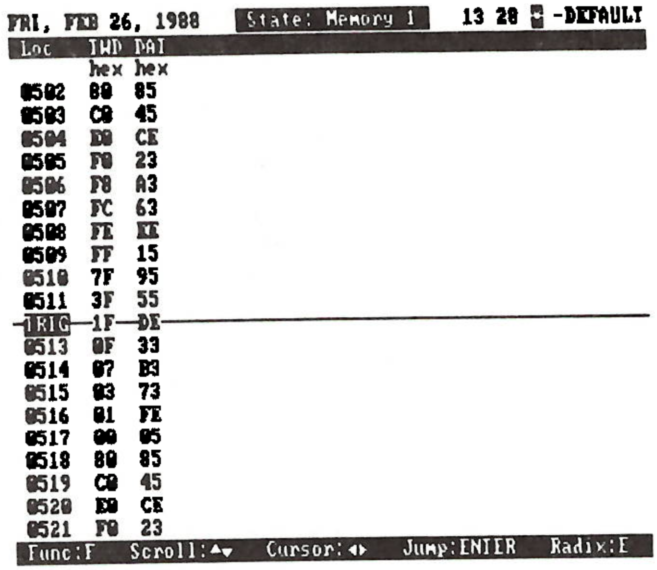

Figure 2-15. State Display for Example 2.

The following steps will take you through some of the more common operations you might wish to perform in the State Menu.

1. MOVING THE DATA CURSOR. Press the left and right arrow keys a few times. Note that this moves the data cursor one memory location at a time. If you know what location you want to look at, you can jump directly to it by pressing ENTER and typing in the location number. Try this by pressing ENTER and typing in 0512, the location that we know from the Run Control Menu will contain the trigger. Note that TRIG is now the first location at the top of the screen.

2. SCROLLING THE DISPLAY. Press the up and down arrow keys a couple of times. Note that the cursor stays in the same place on the screen but the data scrolls up or down by a set number of memory locations. To change the scroll rate, press F until one of the fields in the menu bar is Scroll Rate. Press 7 or 8 until the field matches the number of locations you want the display to move each time the arrow keys are pressed.

3. CHANGING THE DISPLAY RADIX. The default channel group values are shown in hex. However, if you would rather view data in a different radix, you can change it. For example, let's change the radix of the TWD group to binary. Press E to enter screen editor mode. Use the arrow keys to move the cursor to the radix field for TWD. Press 0 until the radix is BIN. Press ENTER to exit editor mode.

4. SEARCHING. The 1230 allows you to search for the beginning or end of the acquisition, for the trigger location, or for any event defined in the Condition Menu. As an example, let's look for the end of the acquisition. Press F until one of the fields in the menu bar is Search for. Press 0 until Acq End is selected. Press 1 to start the search. Note the cursor is now on location 2047, the last location in Memory 1.

EXAMPLE THREE.

Comparing Two Acquisitions to Each Other

OVERVIEW. In this example, we will create a malfunction on the test card by shorting the inputs to a NAND gate together. We will then acquire data using exactly the same setup as was used in Example 2. By comparing the data acquired in each of these examples, we will be able to locate the source of the test card malfunction.

Comparing the output from a known good circuit (reference memory) to the output from a circuit you are unsure of (acquisition memory) is one of the most useful troubleshooting methods available to you. Not only does the 1230 allow you to look at the outputs from two circuits, but it will do the actual comparison for you. When you compare two memories, the locations where the acquisition memory differs from the reference memory will be dim in the state table.
After completing this example, you should know how to:

- load a previously stored setup
- select a different memories for storing acquisitions
- compare different acquisitions
- mask channels

PROBE CONNECTIONS. Connect the probe leads to the test card exactly as in Example 2. Additionally, you must short together U2 inputs 1 and 2. There are two ways to do this. The best way is to use a lead with grabber tips on both ends (such as the white lead that came with your 1230) to jumper pins 13 and 14 on U5, the74HC161 chip (see Figure 2-16).

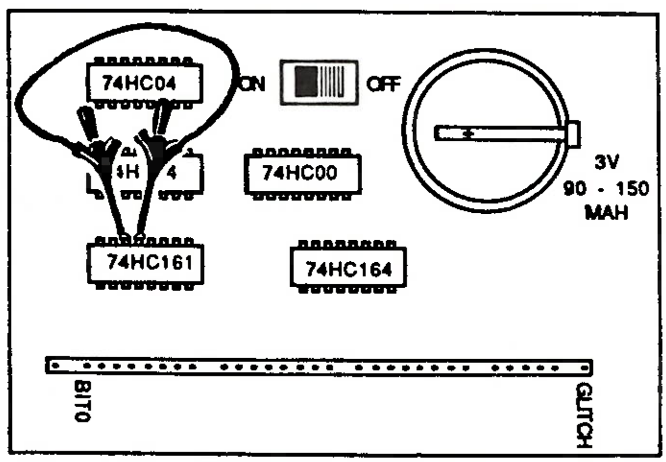

Figure 2-16. Test Card showing U5 pins 13 and 14 shorted.

Another way is to jumper the pins labeled Bit0 and Bit1. If you do it this way, make sure that the lead set connections to those pins are still solid.

INSTRUMENT SETUP. The acquisition setup used in this example is exactly the same as that used in Example 2, except that a different memory will be used to store the acquisition. This is to avoid overwriting the acquisition from Example 2 which is needed for use as a reference memory.

If you saved the setup from Example 2, you can reload it from the Storage Menu. Call the Storage Menu by pressing MENU, followed by B. Press the up and down arrow keys until the arrow points to the setup saved in Example 2 (we called it Set Two). Then press 0 to load it. The 1230 will prompt you to press ENTER to confirm the overwriting of the current setup.

If you didn't save the setup, you will have to make the menu selections individually. Go back and follow the Instrument Setup instructions given in Example 2.

Once the setup is the same as was used in Example 2, make the following menu change:

Run Control – Select 2 in the Update Memory field (see Figure 2-17). This will cause the acquisition to be stored in Memory 2.

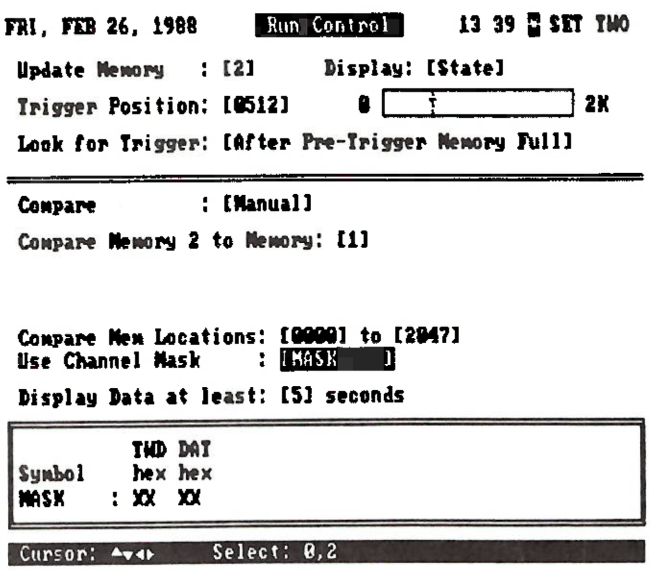

Figure 2-17. Run Control for Example 3 shows Memory 2 selected.

ACQUISITION. Once you have made the required changes to the instrument setup, press START to begin acquiring data. The 1230 will acquire enough data to satisfy the pre-fill memory requirements. It will then start looking for EVENT. When the condition is found, the 1230 will trigger and fill post-trigger memory. The data will be displayed in the State Menu.

MEMORY COMPARISON AND DATA DISPLAY. At this point, Memory 1 should contain good test card output and Memory 2 should contain output showing errors introduced by having two lines together. The next step is to compare the two memories and see how the 1230 can help you locate the short.

Memory comparison is controlled from the lower portion of the Run Control Menu (see Figure 2-17). Enter this menu and make the following changes:

- Select 1 as the memory compared to Memory 2. The number in the Compare Memory field is the current acquisition memory. the same as is selected in the Update Memory field in the upper portion of this menu.

- Set the Compare Mem Locations field for 0000 to 2047 so that we will be comparing all memory locations. To do this, place the cursor on the field and press ENTER to get into edit mode. Key in the desired number, then press ENTER to exit edit mode.
- In the Channel Mask field, select the condition we called MASK.
- The Compare field should be left on Manual.

Now, we're ready to run the comparison. Go back to the State Menu and press F until one of the fields in the menu bar is Compare Mem. This field should be followed by 2-1, indicating that Memory 2 will be compared to Memory 1.

The #Diff field in the menu bar shows how many differences were found. This field should be all zeroes since we haven't actually run the comparison yet.

The rightmost field in the menu bar, Mem, allows you to switch between the Display memory (Memory 2, in this case) and the Reference memory (Memory 1). Which memories are used depends on the selections made in the Run Control Menu.

To run the comparison, press C (for compare).

Note that nothing appears to have happened. All the memory locations are still in regular video and the #Diff field is still zero. This would seem to indicate that the two memories are identical. However, we know this cannot be the case since we shorted two lines together.

The problem is that we didn't change the comparison mask. Look at the Conditions Menu. The event we defined as MASK (and used in the Run Control Menu) is still set to the default of all don't cares. Any channel containing an X is masked. In other words, it is ignored in the memory comparison. So what we did was run a comparison on no channels.

The pins shorted together were selected so as not to affect our trigger word (TWD) so there is no reason to unmask those channels. However, we should compare all the channels in the DAT group. Do this by changing the group value of DAT in MASK to FF_{hex} as is shown in Figure 2-18. This places the equivalent of a binary 1 on each channel. Any value other than X on a channel will cause it to be included in the comparison.

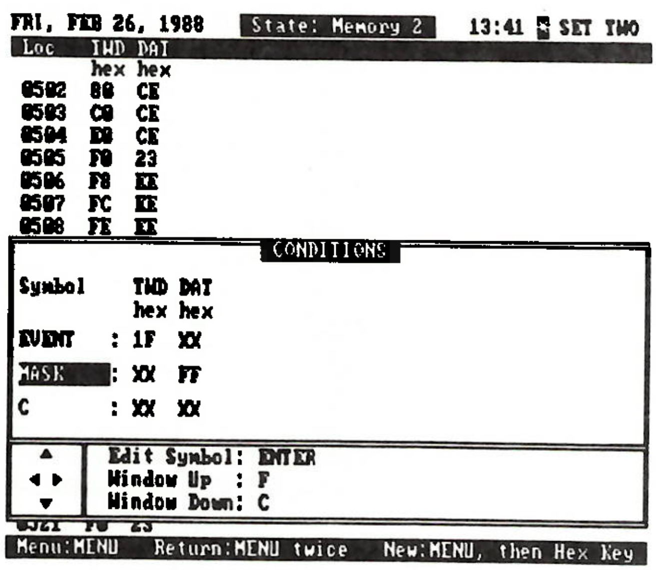

Figure 2-18. Conditions Menu shows all channels in MASK marked for inclusion in the memory comparison.

Go back to the State Menu and press C to run the comparison. There will now be dim locations in the State Table where memory differences occurred in the DAT group (see Figure 2-19).

NOTE

To change the dim locations back to regular video, return to the Run Control Menu and compare the memory to itself.

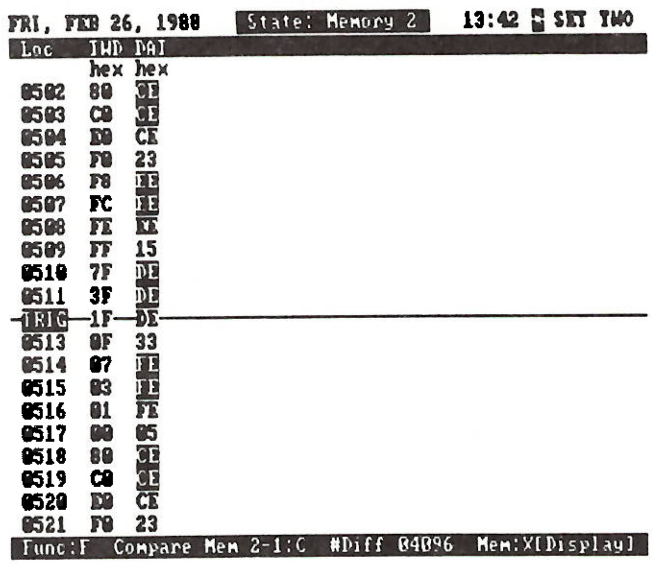

Figure 2-19. State Table contains dim locations where memory differences occurred.

Switch to the Timing Menu by pressing MENU, followed by 9. Note that traces for channels DAT07 and DAT06 (leads D15 and D14) always change states at the same time, clearly showing they are tied together (see Figure 2-20).

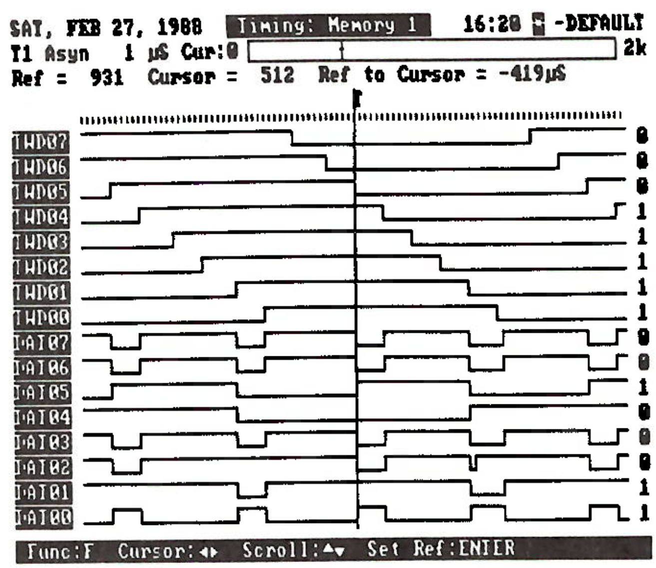

Figure 2-20. Timing Diagram shows DAT07 and DAT06 tied together.

EXAMPLE FOUR

RUNNING AN AUTO COMPARISON

OVERVIEW. In Example 3, we compared an acquisition from a known good circuit to one known to be malfunctioning. In this example, we will run a similar comparison. The difference is that the comparison will take place while the data acquisition is underway. We will acquire data from the test card containing a short as in Example 2. The 1230 will compare the acquired data to the known good reference memory.

Acquisition will continue as long as the memories are unequal. Part way through the acquisition, we will remove the jumper on the test card, thus fixing the circuit malfunction. When the memories are the same, the 1230 will stop acquiring and display data. We will do this twice: once displaying data in the State Menu and once in the Timing Menu.

Acquiring data in Auto mode is often used in parametric testing when the your objective is to verify that circuit components meet their specifications (i.e., threshold sensitivity, rise and fall times). Auto mode is also useful in calibration as it allows you to see the effect of the adjustments you are making while you are making them.

After completing this example, you should know how to:

- run an auto comparison
- set a comparison mask
- change the data display update rate
- change when the trigger is enabled

4A. Running an Auto Comparison

PROBE CONNECTIONS. Initially, the probe connections and jumper should be exactly as they were in Example 3.

INSTRUMENT SETUP. Following the instructions given in Example 3, load the setup SET TWO saved in Example 2. If the setup was not saved, follow the instrument setup instructions given in Example 2. Once the setup is the same, make the following menu changes.

Conditions Menu — Change the DAT channel group of the condition MASK to FF_{hex} so that all DAT channels will be compared (see Figure 2-21).

Run Control Menu — Change the memory to 3 so that the previously acquired data will not be overwritten (see Figure 2-22).

Set the compare field to Auto.

Select 1 as the reference memory compared to Memory 3.

Select Display and Stop as the action performed when memories are equal. Select Display and Reacquire when memories are unequal.

Select MASK in the Channel Mask field.

Change the display rate to 1.

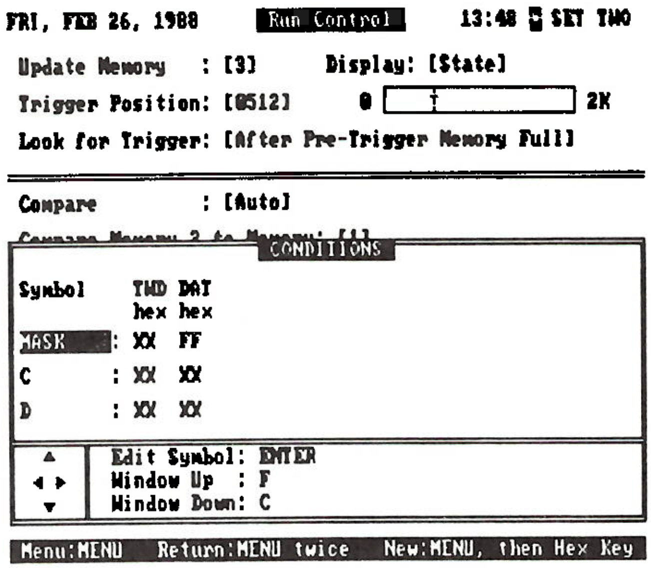

Figure 2-21. Conditions Menu shows the comparison mask to be used in the auto compare acquisition.

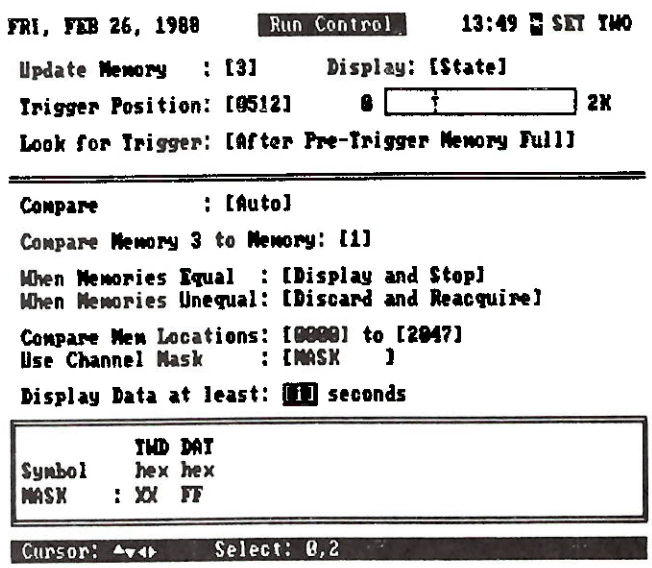

Figure 2-22. Run Control Menu shows selections for running an auto compare acquisition.

ACQUISITION AND DISPLAY. Press START to begin acquiring. The data should be displayed in a state table that gets updated every second. Note that this is a little fast to be able to see much of the data.

Press STOP to end the acquisition.

Return to the Run Control Menu and change the display rate to 7 seconds.

Press START to begin a new acquisition. Now that the screen only gets updated every 7 seconds, you should have time to look at the data. Notice that locations where memory differences were found are dim.

While data is still being acquired, pull the jumper off the test card. The 1230 will stop acquiring and display the latest acquisition (recall that this is the action we selected in the Run Control Menu for equal memories). Since the aquisition memory now matches the reference memory, the data displayed no longer contains any dim locations.

4B. Triggering Continuously

PROBE CONNECTIONS. The connections should be the same as in part A. Reconnect the jumper across U5 pins 13 and 14.

INSTRUMENT SETUP. Set up the Run Control Menu as follows (see Figure 2-23). The rest of the menus should be left as they were in part A.

- Select 3 in the Update Memory field.
- Change the Display field to Timing.
- Change the Look for Trigger field to Continuously. Note that this caused the Compare field to switch to Manual. Looking for the trigger continuously and running an auto compare are contradictory operations.
- Compare Memory 3 to Memory 1 as in part A.
- Select MASK as the channel mask.
- Change the display rate to 1 second. This will make the change more obvious than if you select a slower screen update rate.

```
FRI, FEB 26, 1988       Run Control       14:13   SET TWO

 Update Memory    : [3]       Display: [Timing]
 Trigger Position: [0512]       0 [   †          ] 2K
 Look for Trigger: [Continuously]
 ==============================================================
 Compare          : [Manual]
 Compare Memory 3 to Memory: [1]


 Compare Mem Locations: [0000] to [2047]
 Use Channel Mask      : [MASK    ]
 Display Data at least: [1] seconds

          THD DAT
 Symbol   hex hex
 MASK   : XX  FF

 Cursor: ▲▼◄►        Select: 0,2
```

Figure 2-23. Run Control Menu shows selections for making a continuous acquisition.

ACQUISITION AND DATA DISPLAY. Press START to begin acquiring. The 1230 begins acquiring data continuously. The timing diagram on the screen is updated every second. Pay particular attention to traces DAT07 and DAT06. These are the bits that are tied together so that they always change states at the same time.

Now, while watching traces DAT07 and DAT06, remove the jumper. Note the change in these two traces. Now DAT07 goes through twice as many transitions as DAT06.

Press STOP to end the acquisition.

EXAMPLE FIVE

Verifying the Functionality of a Logic Gate

OVERVIEW. In this example, we will perform a functional test on the NAND gate that was shorted in Examples 3 and 4. We will change the channel grouping so that data displayed in the State Menu looks like a truth table for the gate. In the Timing Menu, we will turn off channels we are not interested in.

Verifying the functionality of a circuit component with a logic analyzer is usually easy. In this case, for example, all we have to do is connect leads to the two inputs and the output of the NAND gate. Looking at the data from these three channels, it will be immediately obvious whether or not the gate performs as it should. Even a simple test like this one is difficult, if not impossible, to do with an oscilloscope.

With a scope, you would have to look at each of the inputs and the output separately. After which, you would still not know exactly when the signals occurred in relation to each other. Even with a dual-channel, storage oscilloscope, confirming the gate's functionality would be much more difficult than with a logic analyzer. Still, it could be done. However, can you imagine how many measurements you would have to make to test even an 8-bit, let alone a 32-bit, microprocessor? With a logic analyzer, you would be able to simultaneously monitor all the inputs and outputs. Oscilloscopes are useful in testing analog circuits when you need to see the actual voltage levels on only a few channels, but testing digital logic systems requires the power and flexibility of a logic analyzer.

Another advantage that logic analyzers have over some other measurement instruments is their ability to trigger on specific events. This allows you to store only data surrounding phenomena you are interested in. Reducing the amount of data you have to acquire in order to capture a specific event lets you do more with less memory and saves you from having to search through irrelevant data.

After completing this example, you should know how to:

- group channels
- change channel group radixes
- define conditions
- change the display radix in the State Menu
- turn off unwanted traces
- search for conditions in the State Menu

PROBE CONNECTIONS. Use the same connections to the test card as were used in Example 2.

INSTRUMENT SETUP. Start with the instrument setup saved in Example 2. Instructions for loading a stored setup are given under *Instrument Setup* in Example 3. If the setup was not saved, follow the instrument setup instructions in Example 2. Starting with this setup, make the following menu changes.

Channel Grouping Menu – Leave the TWD channel group as it is. Change the name of the DAT channel group to IN and assign it channels A15 and A14, the inputs to the NAND gate (see Figure 2-24). Call another channel group OUT and assign it channel A08, the NAND gate's output. Change the radix of both of these groups to BIN.

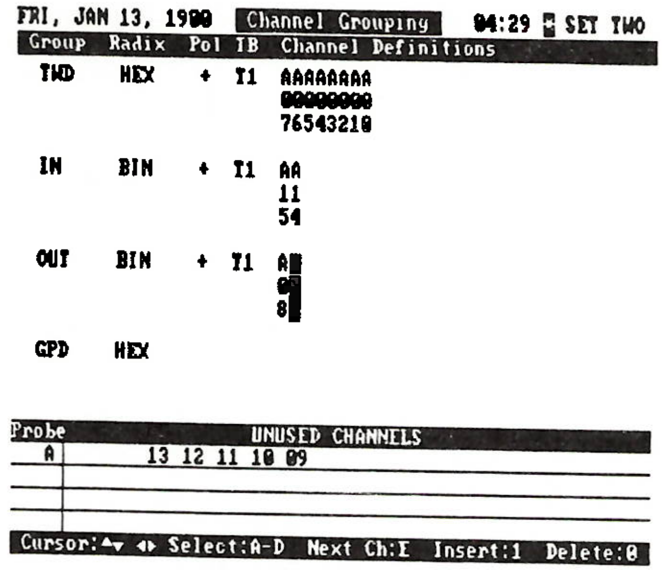

Figure 2-24. Channel Grouping Menu shows input channels grouped together with a separate group for the output.

Conditions Menu – Change EVENT so that we will be triggering on both channels of the IN group being high: TWD and OUT should be all Xs and IN should be 11.

Set up three other condition symbols to cover the other possible states for the input to the NAND gate. Call them 10, 01, and 00 and assign corresponding values to the group IN (see Figure 2-25). If you press F in this menu, it will expand, allowing you to view more conditions at a time.

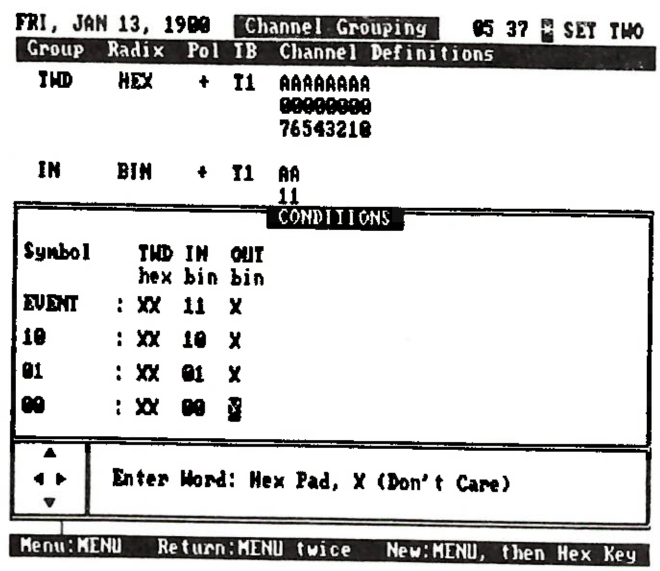

Figure 2-25. Conditions Menu contains a symbol for every possible input to the gate.

Run Control Menu – Select After Pre-Trigger Memory Full in the Look for Trigger field.

ACQUISITION AND DISPLAY. Press START to begin the acquisition. The 1230 acquires data until the pre-fill memory requirements are met. It then starts looking for 11 on the IN channels. When it occurs, the 1230 triggers, fills memory, and displays the data in the State Menu (see Figure 2-26).

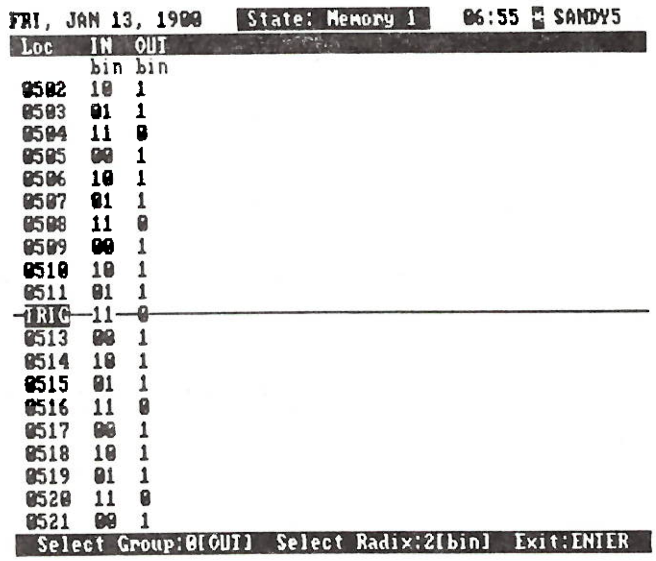

Figure 2-26. State Menu shows gate inputs and output displayed like a truth table. The menu bar shows fields which appear when E is pressed to change the display radices.

Since we are only interested in the channel groups IN and OUT, the data from TWD is unnecessary and it clutters up the screen. To turn off the display of this group, change its radix to off. To do this, press E. The fields in the menu bar will change to Select Group and Select Radix.

Press 0 until the group selected is TWD. Then, press 2 until off is selected as the radix. Press ENTER. The TWD group is no longer displayed (see Figure 2-26).

Move the cursor to the trigger location. The easiest way to do this is to press F until one of the fields in the menu bar is Search for. Select Trigger in this field.

The IN and OUT channel groups form a truth table for the NAND gate. Whenever the value of IN is 11, OUT is 0. For every other combination of IN states, OUT is 1. This is exactly what should be seen for a properly functioning NAND gate.

Change to the Timing Menu by pressing MENU, followed by 9. Locate the two IN traces and the OUT trace. Note the NAND relation between their waveforms (see Figure 2-27).

Since we are not interested in the traces from the TWD channel group, turn off their display by doing the following:

1. Press E to edit traces. The fields in the menu bar will change to show you several editing functions.
2. Press D to select Edit Label as the function being performed. The menu bar will change again.
3. Use the up and down arrow keys to move the cursor to the trace you don't want to view. Then, press 3 to turn off the trace.

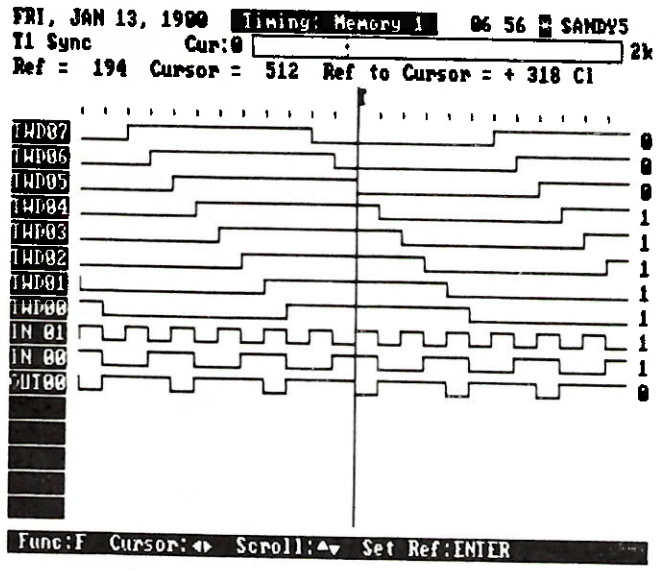

Figure 2-27. Timing Menu shows NAND relation between inputs and output.

EXAMPLE SIX

Counting Events

OVERVIEW. In all the examples so far we have used the same trigger specification. We set the 1230 up to trigger whenever the condition we defined as EVENT occurred. In this example, we will trigger the 10th time an event goes true instead of the first. Choosing different trigger positions, we will repeat this acquisition several times. We will also experiment with changing the Look for Trigger field to Immediately.

This type of measurement is useful if the data surrounding a specific occurrence of an event is what you are really interested in, not just whether or not the event occurs. For example, suppose you are running a program that crashes every 10th time it calls a particular subroutine. A problem of this nature can be very difficult to troubleshoot since it works fine nine out of ten times. In this case, the data around that troublesome 10th iteration is what you want to look at. Or, maybe you suspect that the problem is due to something that happened during the 9th iteration which made it impossible to execute the subroutine a 10th time. In this case, you would set your logic analyzer up to trigger on the 10th occurrence of the event that calls the subroutine. You would set the trigger position such that the 9th occurrence would also be acquired.

After completing this example, you should know how to:

- use the trigger spec to count events
- change the position of the trigger in memory
- set the 1230 to look for the trigger immediately

6A. Varying the Trigger Position in Memory

PROBE CONNECTIONS. Connect the probe to the test card as in Example 2.

INSTRUMENT SETUP. Start by loading the default setup. To do this, simultaneously press NOTES and ENTER, followed by D. Then, set the menus up as follows.

Timebase Menu – Make no changes to this menu. The timebase should be Async at a rate of 1 us.

Channel Grouping Menu – Define two channel groups. You can leave them with the default names of GPA and GPB. Assign channels A07 through A00 to GPA and channels A15 through A08 to GPB (see Figure 2-28).

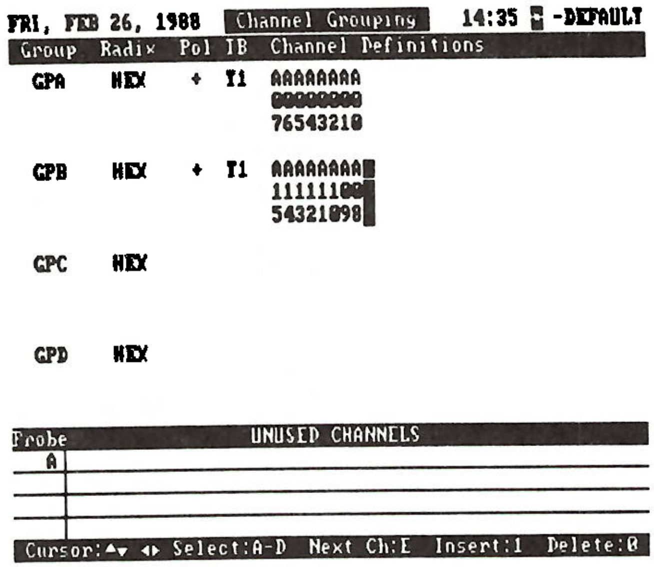

Figure 2-28. Channel Grouping for Example 6.

Conditions Menu – Change one of the symbols to WORD. Change the value of GPA in WORD to FF_{hex} (see Figure 2-29). This is the condition we will use for our trigger event.

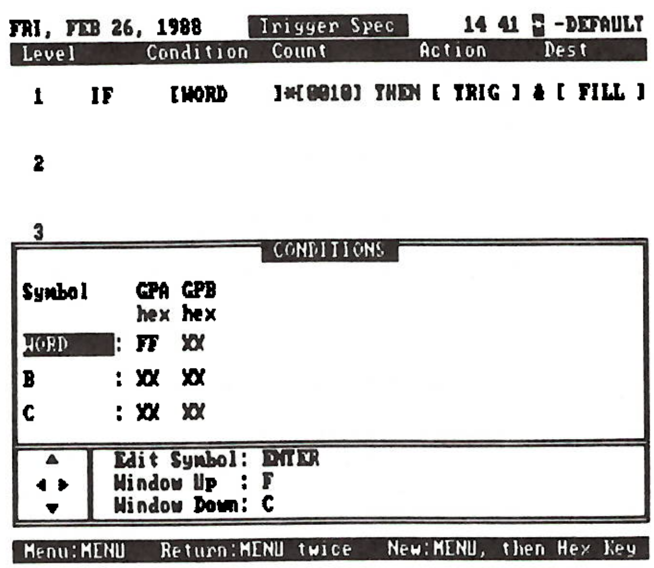

Figure 2-29. Conditions and Trigger Specification sets the 1230 up to trigger on the tenth occurrence of WORD (FF_{hex}).

Trigger Spec Menu – Select WORD as the condition if it is not already in the field. Change the count to 10 (see Figure 2-29).

To change the count, place the cursor on the field and press ENTER to enter editor mode. Type in 0010 to set the count at 10. When you enter the number in the last digit position of the Count field, the 1230 leaves edit mode and the cursor jumps to the Action field. However, if you only change some of the digits in the Count field and the cursor remains on it, you will have to press ENTER to exit edit mode.

Run Control Menu – Place the cursor on the Trigger Position field and press 0 until 1024 is selected. This places the trigger position in the middle of Memory 1.

ACQUISITION AND DISPLAY. Press START to begin acquiring. The 1230 acquires 1023 data samples, then begins looking for channels A07 through A00 being high. When FF is found, the logic analyzer triggers and displays data in the Timing Menu.

The trigger position in the memory domain indicator bar is in the middle. Move the cursor to the trigger position. Note that the cursor location field near the top of the screen identifies the location as 1024, the position we selected in the Run Control Menu.

In the Run Control Menu, change the Trigger Position field to 1920. This is the last location the trigger can be placed in memory. Press START to make a new acquisition.

Place the cursor on the new trigger position. The cursor location will be at location 1920.

6B. Looking for the Trigger Immediately

PROBE CONNECTIONS AND INSTRUMENT SETUP. Use the same connections and setup as was used in part A with the following exceptions: In the Run Control Menu, change the Display field to State and the Look for Trigger field to Immediately. Leave the Trigger Position at 1920 (see Figure 2-30).

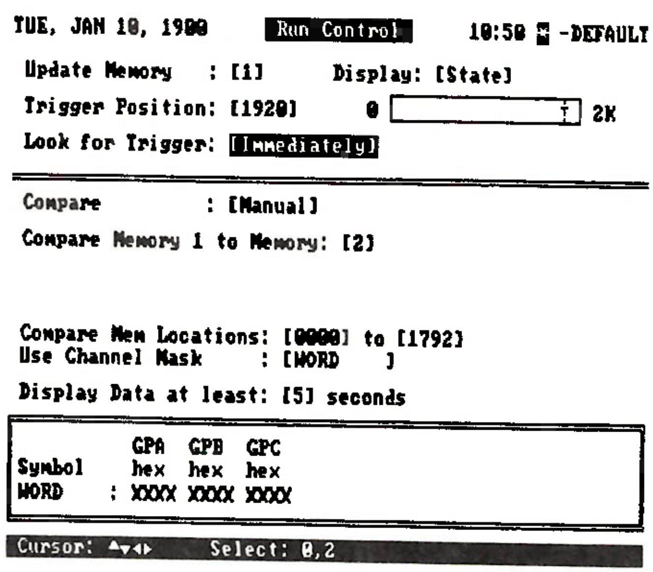

Figure 2-30. Run Control Menu shows the trigger enabled immediately and the trigger position set to location 1920.

ACQUISITION AND DATA DISPLAY. Press START. The 1230 immediately starts looking for WORD. When it occurs the logic analyzer triggers, fills post-trigger memory, and displays data in a state table (see Figure 2-31).

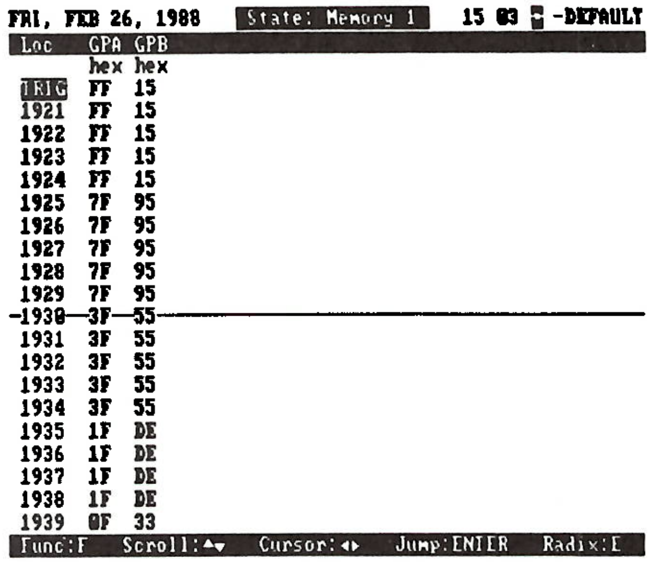

Figure 2-31. State Menu shows the trigger event located at 1920.

Locate the beginning of memory. The fastest way to do this is to select Acq Beg in the menu bar's Search for field, then to press 1 to search for it. Note that the locations near the beginning of memory do not contain valid data. Invalid data is indentified by dim memory location numbers.

The reason so much pre-trigger memory was not filled is because the 1230 started looking for the trigger immediately. When it was found, it was placed in location 1920 and the post-trigger memory was filled. The only pre-trigger memory stored was that which occurred between the beginning of the acquisition and when the trigger condition was recognized. The rest of pre-trigger memory was not filled.

EXAMPLE SEVEN

Triggering on a Sequence of Events

OVERVIEW. This example comprises two parts. In part A, we will set the 1230 up to trigger on a sequence of different events. So far all our examples have used only one trigger level. This one will use two. The 1230 allows you up to 14 levels in your trigger specification.

In part B, we will use the same trigger specification as in part A, but we will use the EXT HIGH input as one of the conditions in the trigger specification. The P6443's EXT inputs are edge-sensitive as opposed to level-sensitive (as are the other inputs). That is, they recognize *when* a signal goes high or low, not just whether it *is* high or low (see Figure 2-32).

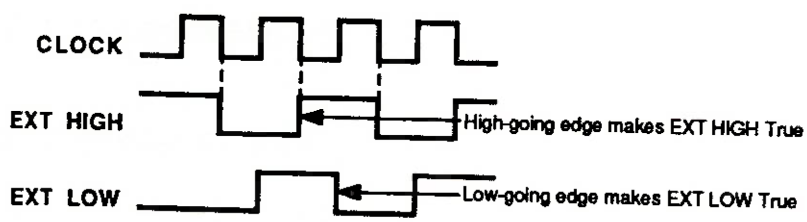

Figure 2-32. Waveform shows when EXT HIGH and EXT LOW are True.

Edge sensing capability is useful when you want to look for a transition on a single line. For example, perhaps the event you want to trigger on is a Bus Grant Acknowledge (BUSAK) that occurs after an NMI (non-maskable interrupt) from a peripheral device. You could connect the EXT LOW input to the NMI line and use that as one trigger level condition. Then, an additional trigger level could be used to recognize the BUSAK.

After completing this example, you should know how to:

- add trigger levels
- trigger on a sequence of events
- use EXT lines to recognize an edge

7A. Two-Word Sequential Triggering

In this example, we will set up the 1230 to trigger if WD2 (0101 on channel group GPB) occurs after WD1 (1111 on GPA).

PROBE CONNECTIONS. Use the same probe connections as were used in Example 1. Remember, always power up the 1230 before turning on the test card.

INSTRUMENT SETUP. Start with the default setup. To load the default, simultaneously press NOTES and ENTER, followed by D. Then, configure the menus as follows.

Timebase Menu -- You don't need to make any changes to this menu.

Channel Grouping Menu -- Assign channels A15 through A12 to GPA, channels A11 through A08 to GPB, and channels A07 through A00 to GPC as shown in Figure 2-33. Remember, channels can only be in one group at a time so you have to delete them from one group before adding them to another. Change the radix of GPA to BIN.

```
SAT, FEB 27, 1988   Channel Grouping        11:03   -DEFAULT
Group  Radix  Pol  IB  Channel Definitions
GPA    BIN    +    T1  AAAA
                       1111
                       5432

GPB    HEX    +    T1  AAAA
                       1100
                       1098

GPC    HEX    +    T1  AAAAAAAA
                       00000000
                       76543210

GPD    HEX

Probe                 UNUSED CHANNELS
    A

Cursor:▲▼ ◄►   Edit name:ENTER     Default Groups:F
```

Figure 2-33. Channel Grouping Menu for Example 7A.

Conditions Menu – Change the symbol A to WD1 and define all the channels in the GPA group as high (1111). This menu is shown in Figure 2-34.

```
FRI, JAN 13, 1900   Trigger Spec        06:09   -DEFAULT
Level      Condition  Count          Action      Dest

1    IF    [WD1       ]*[0001] THEN [ NOP  ] & [CONTIN]

2    IF    [WD2       ]*[0001] THEN [ TRIG ] & [ FILL ]

3                    CONDITIONS
Symbol     GPA  GPB GPC
           bin  hex hex
WD1     :  1111 X   XX
WD2     :  XXXX 5   XX
WD3     :  0000 5   00

 ▲
◄ ►   Enter Word: Hex Pad, X (Don't Care)
 ▼

Menu:MENU   Return:MENU twice   New:MENU, then Hex Key
```

Figure 2-34. Conditions and Trigger Spec Menus for Example 7A.

Change symbol B to WD2 and define GPB as 5_{hex}, the hex equivalent of a binary 0101. In other words, we are looking for the signals on A11 (BIT11) and A09 (BIT13) to be low and the signals on A10 (BIT12) and A08 (BIT15) to be high. Look at the test card's timing diagram, Figure A-1 on the pull out page, to see when this state exists.

Change symbol C to WD3. Define GPA as 0000_{hex}, GPB as 5_{hex}, and GPC as 00_{hex}. In other words, we are looking for all the channels to be low except A10 and A08. This condition will not be here; however, it will be used in subsequent examples.

Trigger Spec Menu – This menu configuration is shown in Figure 2-34 along with a flow chart describing it (see Figure 2-35). Program the first level so that the Condition is WD1, the Count is 1, the Action is NOP, and the Destination is CONTIN. Basically, we are telling the 1230 to do nothing and continue when WD1 occurs.

Add a second trigger level by moving the cursor down to 2 and pressing ENTER. Program this level so that the Condition is WD2, the Count is 3, the Action is Trigger, and the Destination is Fill. This level will cause the 1230 to trigger and fill memory when WD2 occurs for the third time.

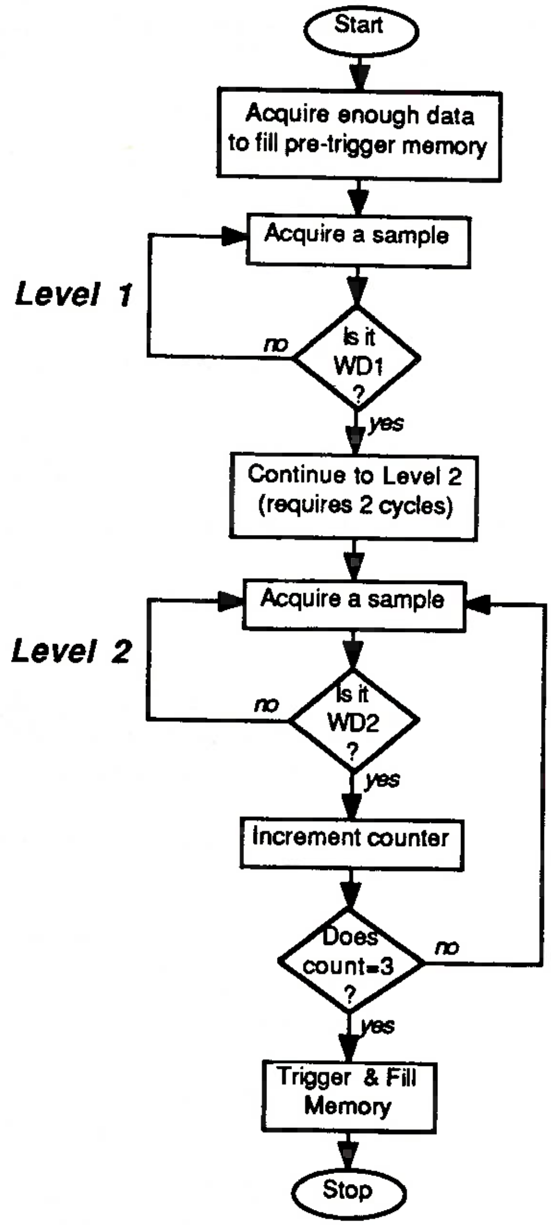

Figure 2-35. Flow chart shows the trigger sequence specified in Figure 2-34.

Storage Menu – Save this setup as SET 7. We will use it again in later examples. Instructions for saving a setup are given under *Instrument Setup* in Example 2.

ACQUISITION AND DATA DISPLAY. Press Start to begin acquiring. The 1230 acquires enough data to fill pre-trigger memory, then it begins looking for WD1 (1111 on GPA). When WD1 is recognized, control moves to trigger level 2 and the 1230 starts looking for WD2 (0101 on GPB). When WD2 is recognized for the third time, the 1230 triggers and fills post-trigger memory. Data is processed and displayed in the Timing Menu.

Enter the State Menu and search for the trigger position by selecting Trigger in the menu bar's Search for field, then pressing 1. The trigger will be at memory location 0512 and have 5 as the value for GPB. For practice, change the display radix to BIN.

7B. Edge Sensing with EXT Lines

In this example, we will set up the 1230 to trigger if WD2 (0101 on channel group GPB) occurs after a transition from logic low to logic high on Bit 7.

PROBE CONNECTIONS. Turn off the test card, then power down the 1230. Leaving all test leads connected as in part A, add the following two connections:

1. Connect the EXT HIGH line to test card pin BIT7.
2. Connect the EXT LOW line to GND. Even though we aren't using this line to acquire data, it is a good idea to tie it low to reduce noise. Similarly, if we were using EXT LOW, EXT HIGH should be connected to a high voltage level.

Power up the 1230. Then, turn on the test card.

INSTRUMENT SETUP. Use the same setup as was used in part A with the following exception: In the Trigger Spec Menu, select External as the condition in Level 1 (see Figure 2-36).

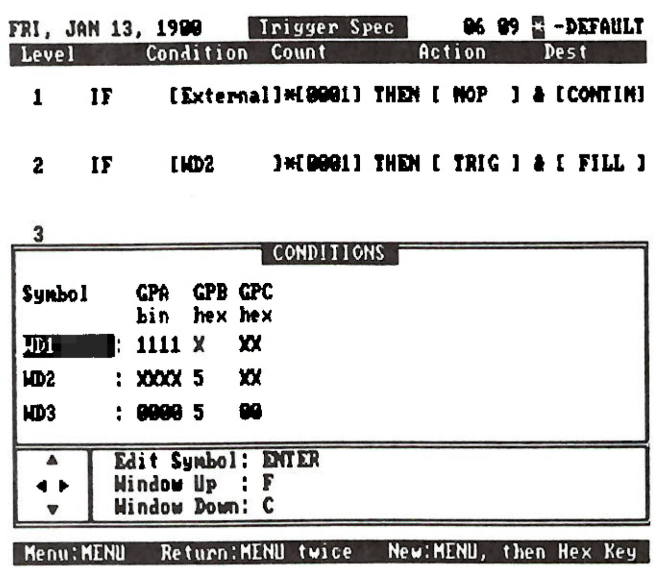

Figure 2-36. Trigger Spec Menu for Example 7B.

DATA ACQUISITION AND DISPLAY. Press Start to begin acquiring. The 1230 acquires enough data to fill pre-trigger memory, then it begins looking for a transition from a low to a high voltage level on the EXT HIGH input (BIT7). When this edge is recognized, control moves to Trigger Level 2 and the 1230 starts looking for WD2 (0101 on GPB) to occur. The third time this state occurs, the 1230 triggers and fills post-trigger memory. Data is processed and displayed in a timing diagram.

In this case the 1230 triggered on WD2, so you know that it occurred after a rising edge on Bit 7.

EXAMPLE EIGHT

Triggering on Event 1 or Event 2

In this example, we will set the 1230 up to trigger when either of two events occurs. The 1230 provides two modes for entering trigger specifications: Basic and Advanced. So far, we have used only Basic mode. The trigger for this example will require Advanced mode.

After completing this example, you should know how to:

- enter a trigger specification using Advanced mode
- set up an ORed trigger

PROBE CONNECTIONS. The probe connections are the same as those used in Example 1.

INSTRUMENT SETUP. Start with the setup from Example 7. If you saved it as Set 7, you can re-load it from the Storage Menu. Otherwise, follow the Instrument Setup instructions in Example 7. Once the setup is loaded, make the following menu changes.

Trigger Spec Menu – Enter Advanced mode by pressing 1. The menu bar will field will include Basic:1 if you are in Advanced mode.

Place the cursor on Level 1 and press ENTER until the second line of Level 1 begins with Else IF (see Figures 2-37 and 2-38).

Select WD1 as the first Level 1 Condition. Set Count to 8 by pressing ENTER to enter editor mode, typing in 0008, then pressing ENTER to exit editor mode. Select TRIG as the Action and Fill as the Destination.

For the second line of the first level, select WD2 as the Condition, TRIG as the Action, and Fill as the Dest.

Delete Level 2 by placing the cursor on it and pressing ENTER until it disappears.

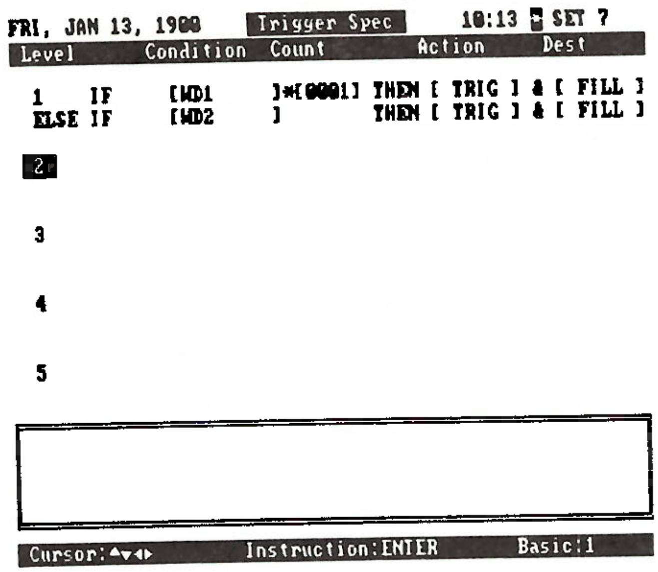

Figure 2-37. Trigger Spec Menu for Example 8 shows an ORed trigger.

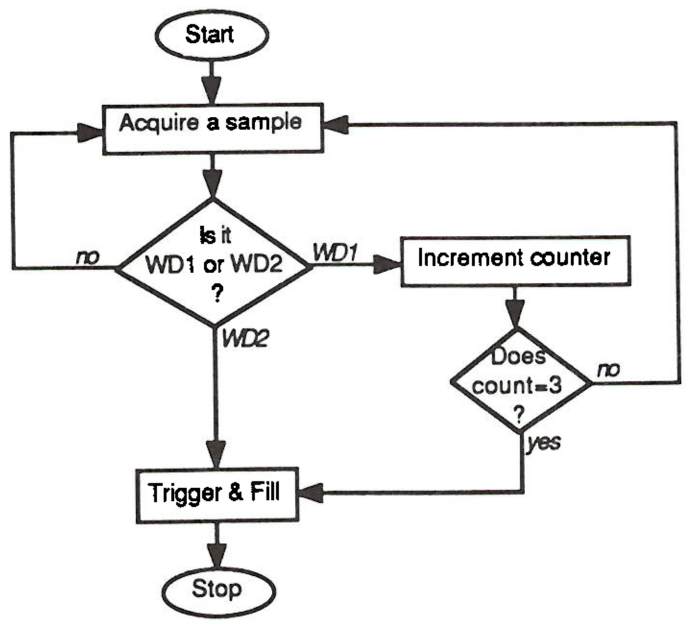

Figure 2-38. Flow Chart for ORed trigger set up in Figure 2-37.

ACQUISITION AND DATA DISPLAY. Press START to begin. The 1230 acquires enough data to fill pre-trigger memory, then starts looking for either WD1 (1111 on GPA) or WD2 (0101 on GPB). Every time WD1 is acquired, the 1230 increments a counter. When the count reaches 8, the 1230 triggers and fills memory. Or, if WD2 occurs before WD1 is acquired eight times, the logic analyzer will trigger and fill memory. Data is processed and displayed in the Timing Menu.

Switch to the State Menu. Does the trigger location contain WD1 or WD2? In this case, it contains WD1 so you know that WD1 occurred at least 8 times before WD2.

EXAMPLE NINE

Looking for a Sequence of Events to Occur within a Specified Interval

OVERVIEW. In this example, we are interested in finding out if the interval between two events is too long or short. Tests of this type are often used to look for setup or hold time violations. For example, maybe you're trying to read from memory and you suspect that the Ready signal is occurring five cycles after the Address Valid signal when it should be occurring six cycles later. Or, perhaps your circuit is not writing data to memory as it should and you want to check to see if data is staying valid long enough.

There are two parts to this example. In part A, we'll acquire synchronously and look for the second event to occur within six cycles after the first. In part B, we will use the 1230's clock and counter to time the interval between events.

After completing this example, you should know how to:

- test whether or not two events occur within a certain number of cycles of each other
- use the async clock rate and the counter to test whether the time interval between two events is longer or shorter than desired

PROBE CONNECTIONS. Connect probes according to the instructions in Example 2.

9A. Measuring an Interval in Synchronous Clock Cycles

The trigger specification in this example tests to see if a condition, WD3, occurs within 6 clock cycles after condition WD1.

NOTE

The 1230 requires two clock cycles to go from one trigger level to the next. This must be taken into account when setting the counter value. In this example, we want to see if WD3 occurs within six clock cycles of WD1 so we will set the counter in level 2 to count four cycles (4 cycles counted + 2 cycles to go from Level 1 to Level 2 = 6 cycles).

INSTRUMENT SETUP. With the exception of the Timebase and Trigger Spec Menus, this example uses the same instrument setup as Example 7. If you saved the setup, reload it from the Storage Menu. Otherwise, follow the instructions in Example 7 for configuring the Channel Grouping and Conditions Menus (see Figures 2-33 and 2-34).

Timebase Menu — Change the clocking format to Sync (see Figure 2-9).

Trigger Spec Menu — In Level 1, check to make sure WD1 is the condition, NOP (no operation) is the action, and CONTIN (continue to the next level) as the destination. Leave the count at 1.

Move the cursor to Level 2 and press 1 to enter Advanced mode. Then, press ENTER until the statement is of the IF...ELSE IF form (see Figures 2-39 and 2-40).

In the first line of Level 2, select Clock as the condition, 4 as the count, TRIG as the action, and FILL as the destination.

In the ELSE IF part of Level 2, select WD3 as the condition, TRIG as the action, and FILL as the destination.

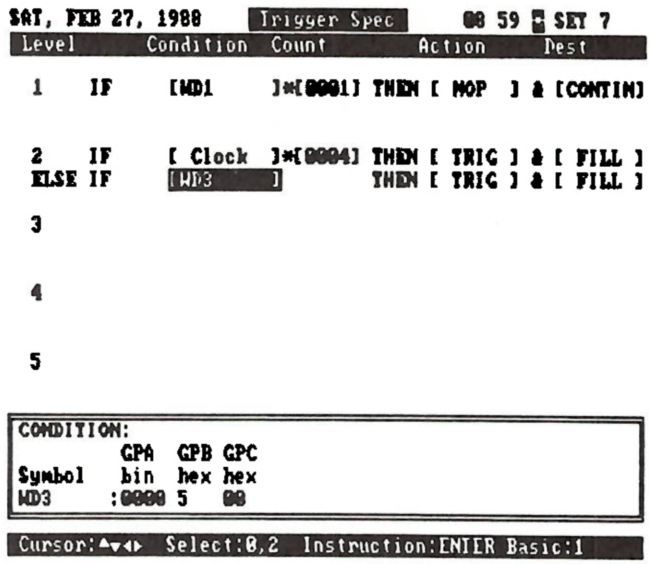

Figure 2-39. Trigger Spec Menu for Example 9A looks for WD3 to occur within six clock cycles of WD1.

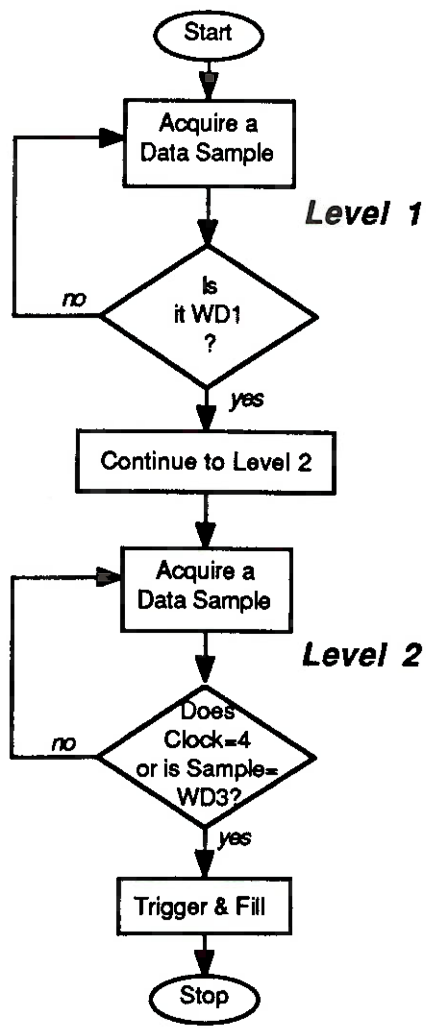

Figure 2-40. Flow Chart for Example 9A's Trigger Specification.

Run Control Menu – Change the display to State.

ACQUISITION AND DATA DISPLAY. Press START to begin. The 1230 acquires enough data to fill pre-trigger memory, then starts looking for WD1 (1111 on GPA). When WD1 is recognized, control is passed to Level 2 and the 1230 starts looking for WD3 (GPA: all low, GPB: 0101, and GPC: all low). If WD3 is acquired within four clock cycles, the 1230 triggers and fills memory. Otherwise, it triggers and fills memory on the 4th clock cycle. Data is processed and displayed in a state table.

Locate the trigger. Does it contain WD3? If not, you know that WD3 did not occur within four clock cycles of WD1. Figure 2-41 shows the State Menu for this acquisition. The trigger location contains WD3 so you know it occurred within four clock cycles of WD1.

SAT, FEB 27, 1988 State: Memory 1 09 01 SET 7

Loc	GPA hex	GPB hex	GPC hex
0502	7	3	03
0503	7	3	03
0504	7	3	03
0505	7	3	03
0506	7	3	03
0507	F	E	01
0508	F	E	01
0509	F	E	01
0510	F	E	01
0511	F	E	01
0512	0	5	00
0513	0	5	00
0514	0	5	00
0515	0	5	00
0516	0	5	00
0517	8	5	80
0518	8	5	80
0519	8	5	80
0520	8	5	80
0521	8	5	80

Func:F Scroll:▲▼ Cursor:◄► Jump:ENTER Radix:E

Figure 2-41. State Menu for Example 9B.

9B. Measuring a Time Interval

The trigger specification in this example uses the 1230's internal clock and the counter to measure time. The clock rate multiplied by the counter value equals the time interval.

Rate x Count = Time

For example, if you are trying to see if condition B occurs within 400 ns after condition A, you could set the rate to 400 ns and the count to 1. Or, to get better resolution, you could set the rate to 100 ns and the count to 4. In general, using the faster clock rate is better because the 1230 cannot recognize an event that occurs within two cycles (or 80 ns, whichever is greater) of the event causing control to be passed from one trigger level to another. Choosing a fast clock rate shortens the real time in which an event could occur and not be recognized.

Because of the test circuit's relatively slow speed, we will test to see if WD3 occurs within 10 μs after WD1.

INSTRUMENT SETUP. Start with the instrument setup used in part A. Then, make the following menu changes.

Timebase Menu – Change the format to Async with a rate of 400 ns (see Figure 2-40).

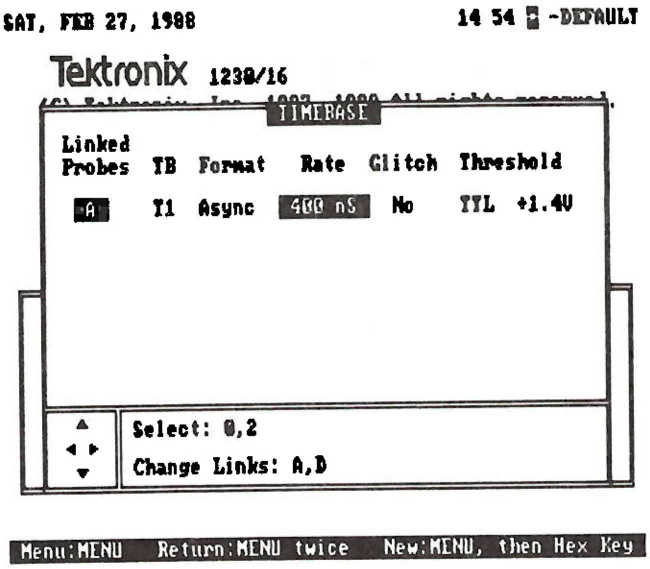

Figure 2-42. Timebase Menu for Example 9B shows an asynchronous clock rate of 400 ns.

Trigger Spec Menu – There is only one field in this menu you must change: set the count in Level 2 to 0023. This menu is shown in Figure 2-43.

At first, it might seem that the count should be 25 since 400 ns per cycle multiplied by 25 cycles would give you the 10 us interval being tested for. However, the transition from Level 1 to Level 2 will require two of those cycles:

25 cycles – 2 cycles to change levels = 23 cycles.

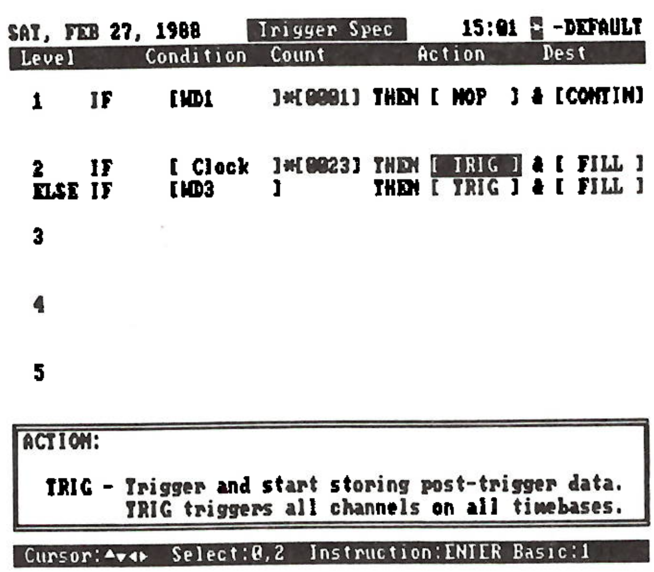

Figure 2-43. Trigger Spec Menu for Example 9B tests to see if WD3 occurs within 10 μs after WD1.

ACQUISITION AND DATA DISPLAY. Press START. The 1230 acquires enough data to fill pre-trigger memory, then starts looking for the first level trigger condition, WD1 (1111 on GPA). After it occurs, control is transferred to the second trigger level (which requires two cycles). The 1230 begins counting clock cycles and looking for WD3. When either WD3 is recognized or the counter reaches 98, whichever occurs first, the 1230 triggers and fills memory. Data is processed and displayed in a state table.

In the State Menu, place the cursor on the trigger location. Does it contain WD3. If not, you know that WD3 did not occur within 10 us after WD1 (see Figure 2-44).

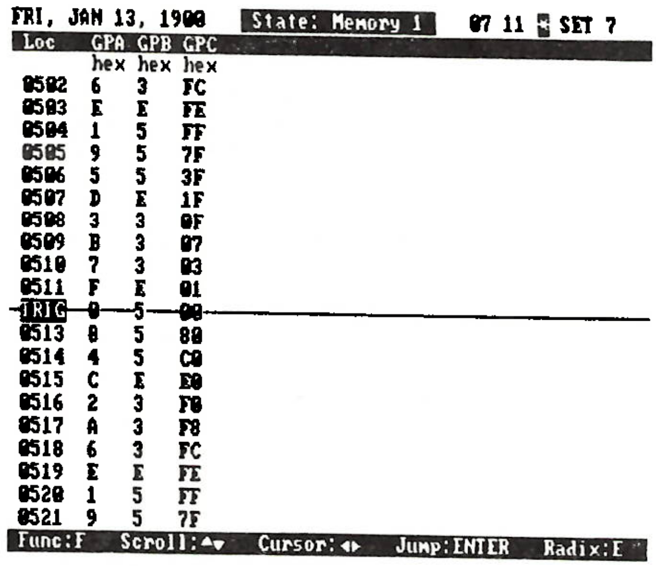

Figure 2-44. State Menu for Example 9B.

EXAMPLE TEN

Looking for an Event During a Specific Interval

OVERVIEW. In Example 9, we were looking to see whether or not event B occurred within a certain number of cycles after event A. This example is similar. However, instead of starting to look for B immediately after A, we will wait a number of cycles before looking for B. In other words, we want to see if event B occurs within a certain interval after A (i.e., between 20 and 50 cycles).

In part A of this example, we will acquire data synchronously and measure the interval in cycles. In part B, we will acquire asynchronously and use the clock rate and a counter to look at a time interval.

Tests of this sort are often used to look for a response to a signal. For example, suppose you are troubleshooting communication between your system and another device such as a printer. The first event you might look for is the one that would initialize the printer. Then, you would look for the event that was the printer's interrupt response. You'd want to make sure the response occurred within a certain interval.

After completing this example, you should know how to:

- use the 1230's EXT HIGH and LOW inputs to monitor single lines
- look for an event within an interval measured in cycles
- use the clock rate and the counter to look for an event during a certain time interval

PROBE CONNECTIONS. Connect the probe to the test card as in Example 2. Then, connect EXT HIGH to BIT8 and EXT LOW to GND.

NOTE

Even if you only plan to use one of the EXT lines in your trigger specification, both should be connected. Tie the unused line to it's True state. That is, if EXT LOW is not being used, it should be grounded. Likewise, if EXT HIGH is not being used, it should be tied to a logical high.

10A. Measuring an Interval in Clock Cycles

The EXT inputs are edge sensitive and so are useful when you want to look for a specific transition on a single channel. They may be selected as conditions in the Trigger Spec Menu. EXT HIGH is True when the signal goes through a transition from logic low to logic high. Likewise, EXT LOW is True when it goes from high to low. If you connect both EXT inputs to active signals, they are ANDed together. That is, for the External condition in the trigger specification to be TRUE, EXT HIGH must go high at the same time that EXT LOW goes low.

In this example, we will check to see if an event, INT, occurs between 10 and 30 cycles after BIT8 (EXT HIGH) goes high.

INSTRUMENT SETUP. Start by loading the default setup (instructions are given in Example 1). Then, make the following menu changes.

Timebase Menu – Change the format to Sync as shown in Figure 2-9.

Channel Grouping Menu – Change the name of GPA to BUS, give it a HEX radix, and assign it channels A15 through A08. Put all other channels in the unused channel list by deleting them (see Figure 2-45).

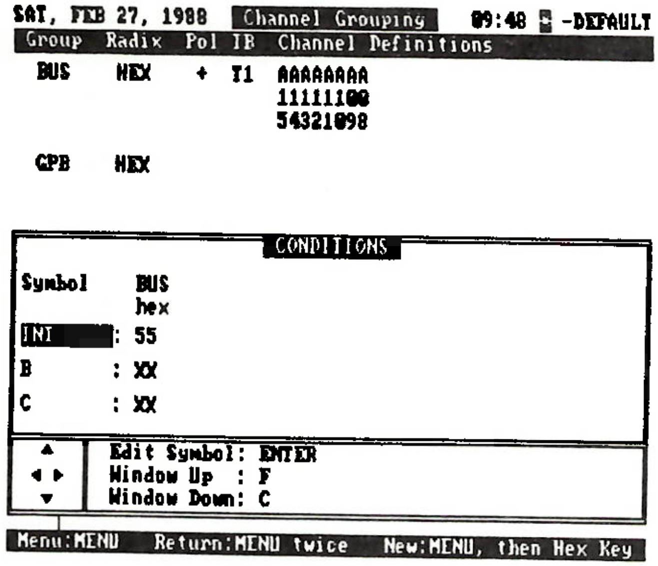

Figure 2-45. Channel Grouping and Conditions Menus for Example 10A.

Conditions Menu – Change the symbol A to INT and define it as 55_{hex} as shown in Figure 2-45.

Trigger Spec Menu – Press 1 to enter Advanced mode.

Set up Level 1 so that the condition is External, the count is 1, the action is NOP, and the destination is CONTIN (see Figures 2-46 and 2-47).

Move the cursor to Level 2 and press ENTER to make it an IF statement. Set the condition to Clock, the count to 8, the action to NOP and the destination to CONTIN. We want to wait 10 clock cycles after the External signal before continuing to Level 3. However, the count is set to 8 because two cycles passed while the 1230 was going from Level 1 to Level 2.

NOTE

The counter is always reset to zero when the 1230 goes from one trigger level to another.

Move the cursor to Level 3 and press ENTER until the statement is of the IF ... ELSE IF form. Set the IF condition to Clock, the count to 18, the action to TRIG, and the destination to FILL. The count is set to 18 rather than 20 because of the two cycles lost while control moved from Level 2 to Level 3.

Set the ELSE IF condition to INT, the action to TRIG, and the destination to FILL.

```
FRI, JAN 13, 1900      Trigger Spec       07:18 ▪ -DEFAULT
Level          Condition  Count          Action      Dest

 1     IF      [External]*[0001] THEN [  NOP   ] & [CONTIN]

 2     IF      [ Clock   ]*[0008] THEN [  NOP   ] & [CONTIN]

 3     IF      [ Clock   ]*[0018] THEN [ TRIG ] & [ FILL ]
ELSE   IF      [INT      ]        THEN [ TRIG ] & [ FILL ]

 4

 5

DESTINATION:

  FILL - Fill the rest of acquisition memory. Use FILL
         with actions TRIG or TRIG 0.

Cursor:▲▼◄► Select:0,2  Instruction:ENTER Basic:1
```

Figure 2-46. Trigger Spec Menu for Example 10A looks for WD3 between 10 and 30 cycles after a high-going signal on the External input.

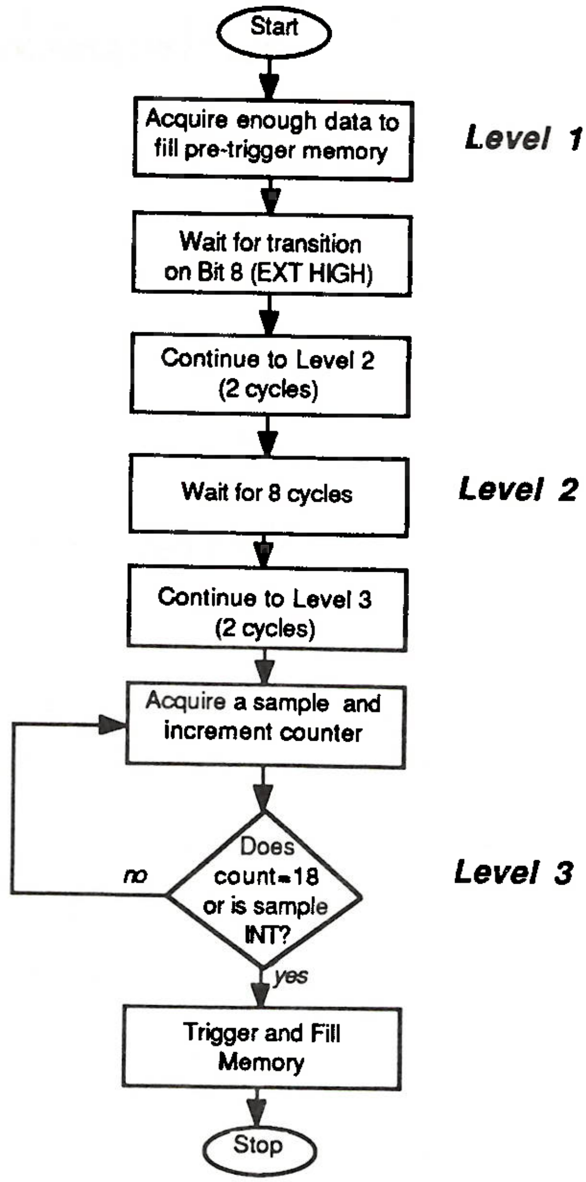

Figure 2-47. Flow chart for the trigger specification shown in Figure 2-46.

Run Control Menu – Select *State* in the Display field.

ACQUISITION AND DATA DISPLAY. Press START. The 1230 acquires enough data to fill pre-trigger memory, then starts looking for a rising edge on the EXT HIGH input. When it is sensed, control is transferred to Level 2 (requires two cycles) and the 1230 starts counting clock pulses on the CLK HIGH input. When the count reaches 8, control is transferred to Level 3 (requires two cycles) and the counter is reset to 0. The 1230 starts looking for INT (55_{hex} on the channel group BUS) while counting clock cycles. When either INT occurs or the count totals 18, the 1230 triggers and fills memory. Data is processed and displayed in a state table.

Locate the trigger in the State Menu (see Figure 2-45). Does it contain 55_{hex}? If so, you know that INT occurred between 10 and 30 cycles after BIT8 went high.

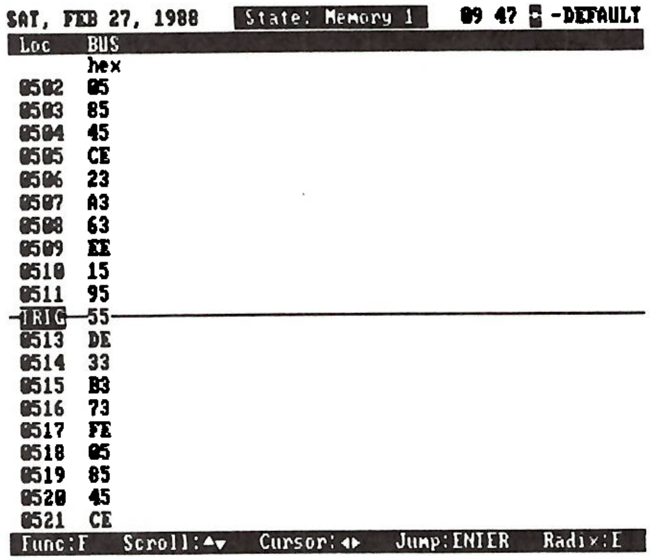

Figure 2-48. State Menu for Example 10A.

10B. Measuring an Interval in Time

Sometimes you are more interested in seeing if an event occurred during a certain time interval rather than within a number of clock cycles. To make time measurements, you can use the 1230's internal clock in conjunction with the counter. This is explained in more detail in Example 9.

In this example we will use the clock and counter to determine if an event, INT, occurs between 10 and 15 μs after BIT8 goes high.

PROBE CONNECTIONS. Start with the same connections as were used in part A. Then, disconnect the CLK HIGH input.

INSTRUMENT SETUP. Start with the same setup as was used in part A. Then, make the following menu changes.

Timebase Menu – Change the format to Async with a rate of 200 ns (see Figure 2-49).

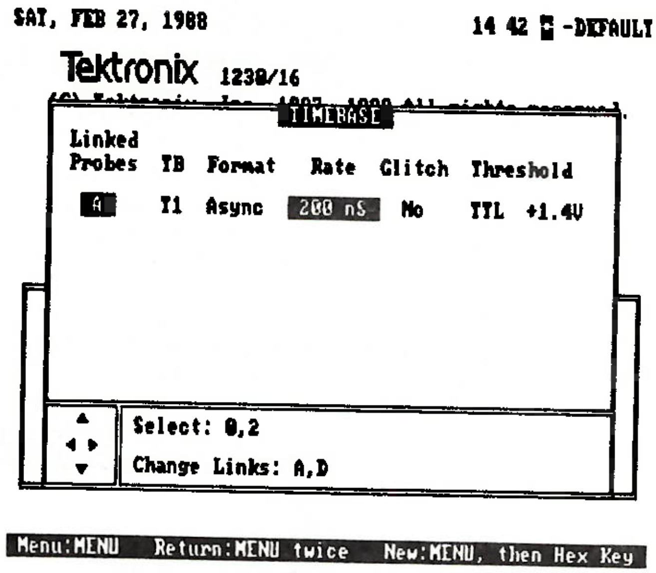

Figure 2-49. Timebase Menu for Example 10B shows 200 ns asynchronous sampling rate selected.

Trigger Spec Menu – Change the count in Level 2 to 48 cycles because

(2 cycles between levels + 48 cycles counted) x 200 ns/cycle = 10 μs.

Also change the count in Level 3 to 23 (see Figure 2-50):

(2 cycles between levels + 23 cycles counted) x 200 ns/cycle = 5 μs

NOTE

When the 1230 goes from one trigger level to another, the counter is reset to zero. This is the reason the interval in Level 3 is 5 μs rather than 15 μs.

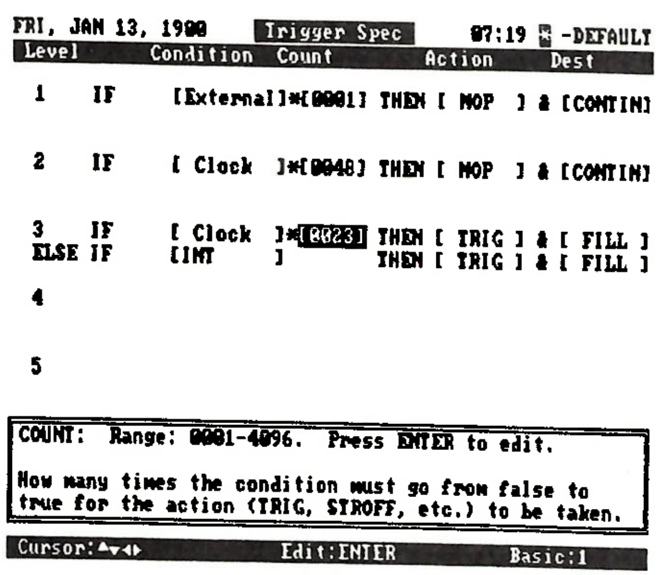

Figure 2-50. Trigger Spec Menu for Example 10B looks for WD3 to occur between 10 ands 15 μs after a high-going signal on BIT8.

ACQUISITION AND DATA DISPLAY. Press START to begin acquiring. The 1230 acquires enough data to fill pre-trigger memory, then starts looking for the signal on EXT HIGH to go high. When this transition is sensed, control is transferred to Level 2 (requires two cycles) and the 1230 starts counting 200 ns clock cycles. When the count reaches 48 (10 μs after the signal on EXT HIGH), control is transferred to Level 3 (requires two cycles) and the counter is reset to 0. The 1230 then starts counting clock cycles again and looking for INT. When either the count reaches 23 (5 μs after the count in Level 2 reached 48) or INT occurs, the 1230 triggers and fills memory. Data is processed and displayed in a state table (see Figure 2-51).

Locate the trigger position in the state table. Does it contain 55_{hex}? In this case, the trigger position does not contain 55_{hex} so you know that INT failed to occur between 10 and 15 μs after BIT8 went high.

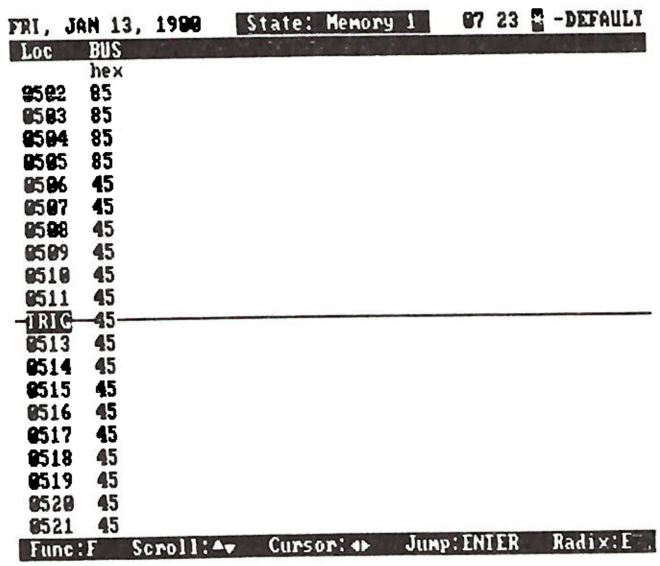

Figure 2-51. State Menu displays the acquisition from Example 10B.

EXAMPLE ELEVEN

Triggering on a Glitch

A glitch is any signal that makes two or more transitions through the threshold voltage level during one clock pulse. Signals like these are usually symptoms of a malfunctioning circuit. Frequently they are caused by capacitive coupling between circuit board traces, by power supply ripples, by high instantaneous current demands from several devices at the same time, or by any number of other undesirable events. Most glitches can be ignored. However, when you are working with sequential, clocked components such as flip-flops and counters, glitches can cause your circuit to behave unpredictably.

Glitches are difficult to detect because they last for so short a time and tend to occur irregularly. The 1230 can be set to trigger on glitches, thus giving you a convenient tool for observing them.

You can select three types of glitches to be recognized: only those going from low to high (rising edge), from high to low (falling edge), or either high-going or low-going (generic).

In this example, we will look for glitches occurring at the same time on three different channels. Using the test card as our SUT, we will look for a high-going glitch on BIT9, a low-going glitch on BIT12, and any glitch on GLITCH to occur at the same time as a specific data word.

When one or more glitches are selected in a given condition, they get ANDed together. That is, they must occur at the same time for the condition to be TRUE.

Specifying an event to be True for the glitch to be recognized, as we are doing in this example, is called *qualifying the glitch.* That is, we are only interested in glitches that occur at certain times.

Looking for glitches that occur concurrently with other events is a common trouble-shooting technique. For example, suppose you had a counter in your circuit that counted clock cycles during DMAs (direct memory accesses). The only times you would be interested in glitches on the clock line would be during DMAs because that would be the only time the counter was enabled.

After completing this example, you should know how to trigger on a glitch.

PROBE CONNECTIONS. With both the 1230 and the test card powered down, connect Probe A to the 1230. Connect the probe leads to the test card pins as follows:

Table 2-2
PROBE TO TEST CARD CONNECTIONS

Input	Pin
D0	GLITCH
D1	BIT9
D2	BIT12
D3	BIT23
D4	BIT22
D5	BIT21
D6	BIT20
D7	BIT19
GND	GND

Once all the connections have been made, power on the 1230. Then, power on the test card.

INSTRUMENT SETUP. Start with the default setup, then make the following menu changes.

Timebase Menu – Turn on glitches by selecting Yes in the Glitch field (see Figure 2-52). When you press MENU to exit this menu, you will be prompted to press ENTER to confirm the change to glitches enabled. The confirmation is required because turning on glitch detection will cause changes in the Channel Grouping Menu.

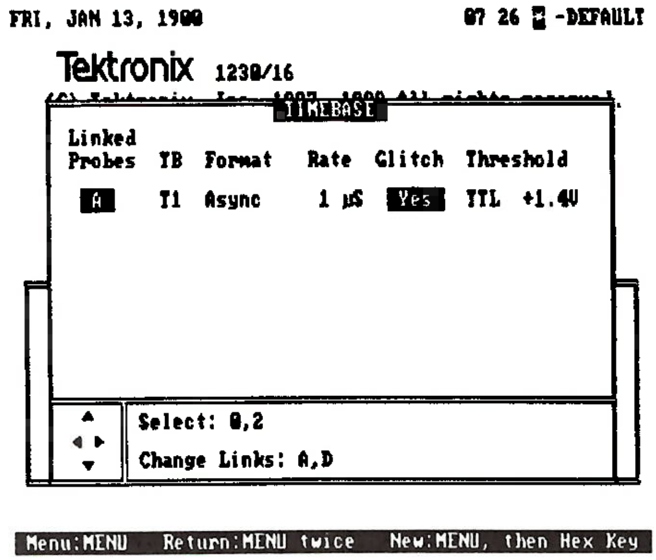

Figure 2-52. Timebase Menu for Example 11 shows glitch detection turned on.

Channel Grouping Menu – Note that only channels A07 through A00 are available (see Figure 2-53). This is because data can only be acquired on the lower eight bits when glitches are turned on.

Change GPA to BUS and assign it channels A07 through A00. Change its radix to BIN. Binary is the only radix in which glitches can be specified in the Conditions Menu.

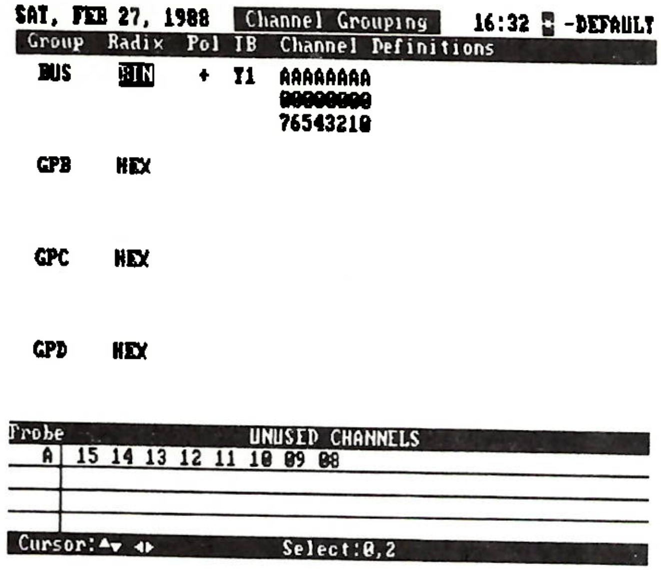

Figure 2-53. Channel Grouping Menu for Example 11 shows only eight channels are available when glitch detection is enabled.

Conditions Menu – Change A to TROUBLE and define it as:

- a falling-edge glitch on A02
- a rising-edge glitch on A01
- a generic glitch on A00
- 0 on A04
- 0 on A05.

Leave the other channels set to don't care (see Figure 2-54).

NOTE

When the cursor is placed on the channel group fields in the Conditions Menu, and the radix is binary, the lower portion of the menu will list the keystrokes for the different glitch symbols: 2 enters a generic glitch, 3 enters a rising-edge glitch, and 4 enters a falling-edge glitch.

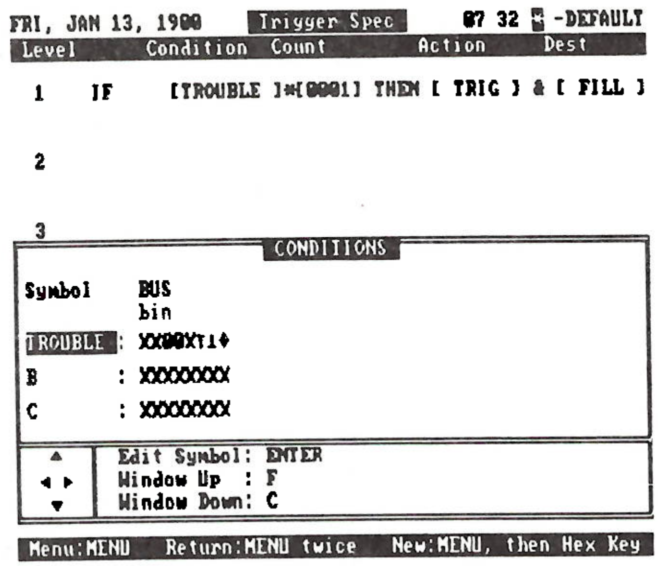

Figure 2-54. Conditions and Trigger Spec Menu for Example 11. Simultaneous glitches are being looked for on three channels.

Trigger Spec Menu – Set up Level 1 so that the condition is TROUBLE, the count is 1, the action is TRIG, and the destination is FILL (see Figure 2-54).

ACQUISITION AND DATA DISPLAY. Press START to begin the acquisition. The 1230 acquires enough data to fill pre-trigger memory, then starts looking for the condition TROUBLE (that is, glitches occurring simultaneously on channels A01 through A00). When it is recognized, the 1230 triggers and fills memory. Data is processed and displayed in a timing diagram (see Figure 2-55).

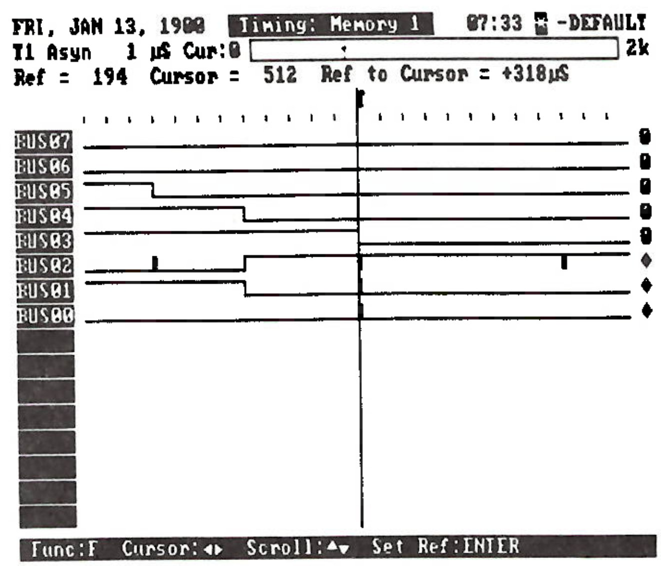

Figure 2-55. Timing diagram from Example 11 shows glitches on channels BUS02 - BUS00.

Locate the trigger position in the Timing Menu. At that location, small vertical bars on traces BUS02, BUS01, and BUS00 indicate that glitches occurred on these channels. Bars rising from the trace are rising-edge glitches while bars descending are falling-edge glitches. The display will show the glitch type even if you specified a generic glitch in the condition.

EXAMPLE TWELVE

Acquiring Iterations of a Subroutine

OVERVIEW. In this example we are going to set the 1230 up as we would if we were trying to find an error in a particular subroutine. We will start storing data on the beginning address of the subroutine. If the error occurs before the ending address of the subroutine, we will trigger. Otherwise, we will stop storing until the subroutine is executed again, at which time we will look for the error again.

There are a number of reasons why you might want to acquire only iterations of a particular subroutine. One is to find an error, as we are doing in this example. Another is to measure its execution time. Reducing the execution times of your subroutines increases the performance of your software. Any time saved in a subroutine is time that can be used to perform additional tasks.

After completing this example, you should know how to use the to store only iterations of a specific subroutine.

PROBE CONNECTIONS. Use the same connections as were used in Example 2.

INSTRUMENT SETUP. Start with the default setup, then make the following menu changes.

Timebase Menu – Change the format to Sync as is shown in Figure 2-9.

Channel Grouping Menu – Change GPA to ADD (for address) and assign it channels A15 through A00 (see Figure 2-56).

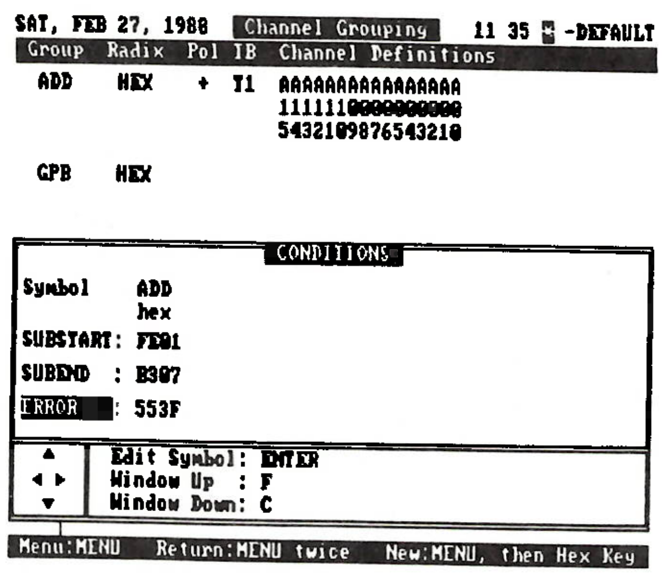

Figure 2-56. Channel grouping and condition definitions used in Example 12.

Conditions Menu – Change the symbol A to SUBSTART and define it as FE01*hex*. This will serve as the starting address of our subroutine (see Figure 2-56).

Change the symbol B to SUBEND and define it as B307*hex*. This will serve as the ending address of our subroutine.

Change the symbol C to ERROR and define it as 553F*hex*.

Trigger Spec Menu – Press 1 to enter Advanced mode. In Level 1, select SUBSTART as the condition, STR ON as the action, and CONTIN as the destination (see Figure 2-57).

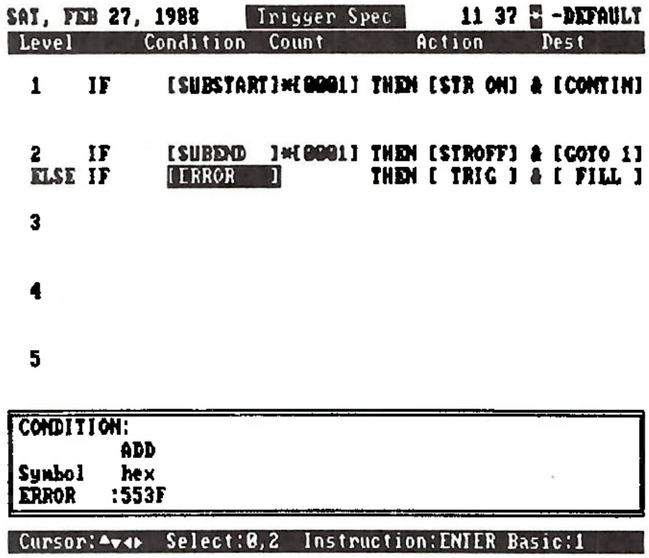

Figure 2-57. Trigger specification used in Example 12 looks for ERROR to occur within a subroutine.

Place the cursor on Level 2 and press ENTER until the statement is of the IF...ELSE IF form. In the IF part of the statement, select SUBEND as the condition, STROFF as the action, and GOTO 1 as the destination.

In the ELSE IF part of Level 2, select ERROR as the condition, TRIG as the action, and FILL as the destination.

Run Control Menu – Select State as the display type. Most software applications require state table displays because of the number of channels you are monitoring.

Move the trigger position to 1664. We are more interested in the events that occurred before the error (and possibly caused it) than we are in events that happened afterwards.

ACQUISITION AND DATA DISPLAY. Press START to begin the acquisition. The 1230 acquires enough data to fill pre-trigger memory, then starts looking for the beginning of the subroutine, SUBSTART. When it is recognized, the 1230 begins storing data and looking for either ERROR or the end of the subroutine, SUBEND. If the error is recognized, the 1230 triggers and fills memory. If the subroutine ends before ERROR occurs, data storage stops and control is transferred back up to Level 1 and the process is repeated. If ERROR never occurs inside the subroutine, you will have to manually halt the acquisition by pressing STOP.

NOTE

The minimum time between triggers levels is two clock cycles. Therefore, if the subroutine is re-entered on the clock cycle following the one it exited on, the 1230 would miss the second entry. However, for most situations, this does not represent a significant limitation.

In the State Menu, press ENTER until one of the fields in the menu bar at the bottom of the screen is SEARCH FOR. Use it to find the trigger position. It will contain the value we defined as ERROR (553F$_{hex}$). Next search for SUBSTART, then for SUBEND. Note that the state defined as ERROR occurs between them (see Figure 2-58).

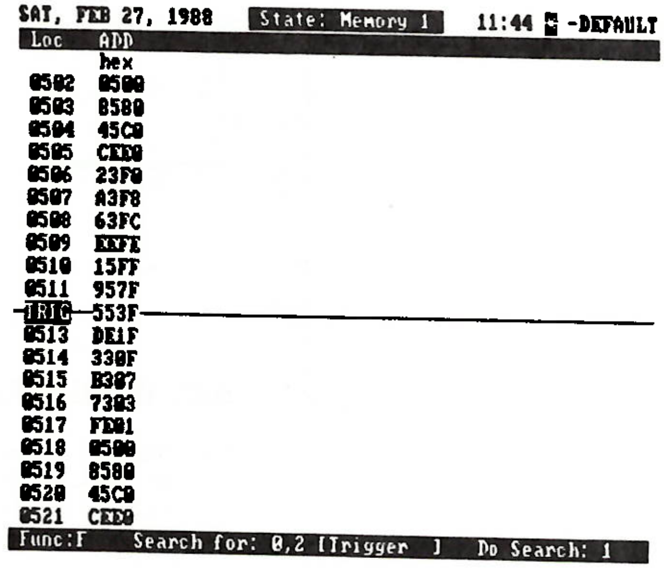

Figure 2-58. State table shows that ERROR occurred within the subroutine.

Since the test card repeats the same 16 states over and over again, we know we will always get ERROR if we define it as a state which occurs between the states we call SUBSTART and SUBEND.

In the Conditions Menu, define ERROR as FFFF and re-run the acquisition. This time ERROR will not occur between SUBSTART and SUBEND. In the Acquisition Status Menu, you will see the trigger level toggle back and forth between Levels 1 and 2.

To halt the acquisition, press STOP. The trigger position will be at the point where you stopped the acquisition (see Figure 2-59). Note that subsequent locations are dimmed in the display and contain no data.

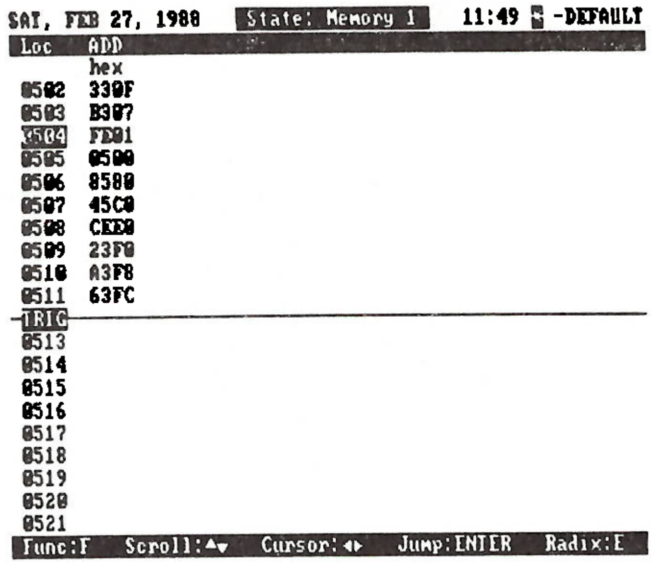

Figure 2-59. State Menu showing data from a manually halted acquisition. Locations following the point where STOP was pressed contain no data.

EXAMPLE THIRTEEN

Acquiring an Address Range

OVERVIEW. In this example, we will set up the 1230 to store only values that occur within a specified range. Ranges are specified by defining conditions that have don't care characters for the lower-order bits. For example, the condition $002X_{hex}$ would give us a range from 0020_{hex} to $002F_{hex}$, $FXXX_{hex}$ would specify the range from $F000_{hex}$ to $FFFF_{hex}$, and so on. Conditions defined as ranges are useful if you are only interested in a specific address range or block of memory. The setup used in this example stores only values within the range 8100_{hex} through $81FF_{hex}$.

In this example we want to look at a portion of diagnostic software that occurs whenever we power up our circuit. Suppose our system generates a reset vector (call it BEGIN) as soon as the power supply becomes stable (see Figure 2-60). We are not interested in acquiring any data prior to BEGIN, since it is all invalid. After BEGIN, our system spends 128 clock cycles in initialization, data from which we are also not interested in. After the 128 cycles, our system runs a memory test routine, a portion of which is what we want to acquire (say, anything from address range 8100 to 81FF). Just in case our circuit bypasses the portion of memory we are interested in, we will choose a value which occurs later on to terminate the acquisition on (call it INVALID).

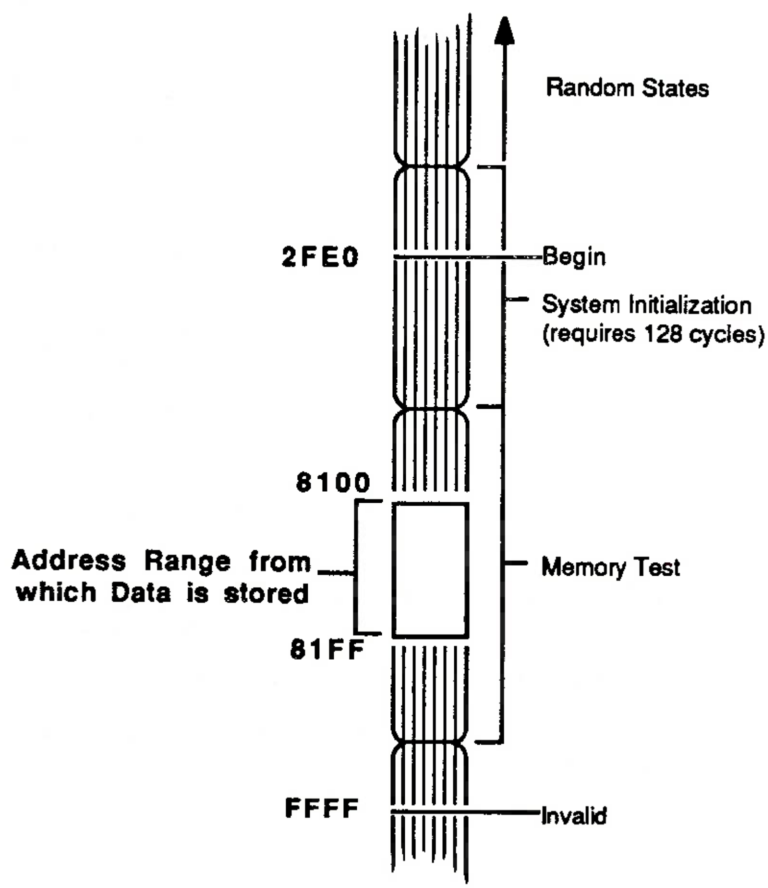

Figure 2-60. Vertical memory map shows the hypothetical system from which data is being acquired.

After completing this example, you should know how to:

- define a range as a condition
- store only certain values
- start looking for the trigger immediately

PROBE CONNECTIONS. With both the 1230 and the test card turned off, connect the probe leads to the test card as follows.

Table 2-3
PROBE TO TEST CARD CONNECTIONS (EXAMPLE 13)

Input	Pin
D0	BIT16
D1	BIT17
D3	BIT18
D3	BIT19
D4	BIT20
D5	BIT0
D6	BIT1
D7	BIT2
GND	GND
D8	BIT3
D9	BIT4
D10	BIT5
D11	BIT6
D12	BIT7
D13	BIT8
D14	BIT9
D15	BIT10
GND	GND
CLOCK HIGH	CLK1

After all the connections are made, power up the 1230. Then, turn on the test card.

CAUTION

Never connect a powered-up SUT to a powered down 1230. Doing so could damage the probe.

INSTRUMENT SETUP. Load the default setup by simultaneously pressing NOTES and ENTER, followed by D (for Default). Then, make the following menu changes.

Timebase Menu — Change the clock format to Sync as shown in Figure 2-9.

Channel Grouping Menu — Change GPA to ADD (for address) and leave all Probe A channels assigned to it (see Figure 2-61).

```
SAT, FEB 27, 1988   Channel Grouping      12:32   -DEFAULT
 Group  Radix  Pol IB  Channel Definitions
 ADD    HEX    +  T1   AAAAAAAAAAAAAAAA
                       1111110000000000
                       5432109876543210

 GPB    HEX

                    CONDITIONS
Symbol     ADD
           hex
BEGIN    : 2FE0
RANGE    : 81XX
INVALID  : FFFF

  ▲   Edit Symbol: ENTER
 ◄ ►  Window Up  : F
  ▼   Window Down: C
Menu:MENU   Return:MENU twice   New:MENU, then Hex Key
```

Figure 2-61. Channel Grouping and Conditions Menus for Example 13.

Conditions Menu – Change the symbol A to BEGIN and define it as 2FE0*hex*. This will be our reset vector, which occurs when the power supply output becomes stable (see Figure 2-61).

Change the symbol B to RANGE and define it as 81XX*hex*. This will give us a range of addresses from 8100*hex* to 81FF*hex*.

Change the symbol C to INVALID and define it as FFFF*hex*. This will be the location that lets us know we are outside the block of memory we are interested in.

Trigger Specification – Press 1 to enter Advanced mode. In Level 1, select BEGIN as the condition, NOP as the action, and CONTIN as the destination (see Figures 2-62 and 2-63).

```
SAT, FEB 27, 1988    Trigger Spec       12 21   -DEFAULT
Level        Condition  Count          Action     Dest
 1   IF    [BEGIN   ]*[0001] THEN [ NOP  ] & [CONTIN]

 2   IF    [ Clock  ]*[0124] THEN [ NOP  ] & [GOTO 3]

 3   IF    [INVALID ]*[0001] THEN [ TRIG ] & [ FILL ]
ELSE STORE ONLY         [RANGE    ]
 4

 5

CONDITION:
           ADD
Symbol     hex
RANGE     :81XX
Cursor:▲▼◄►  Select:0,2  Instruction:ENTER Basic:1
```

Figure 2-62. Trigger Spec Menu for Example 13 shows that only values falling within RANGE will be stored.

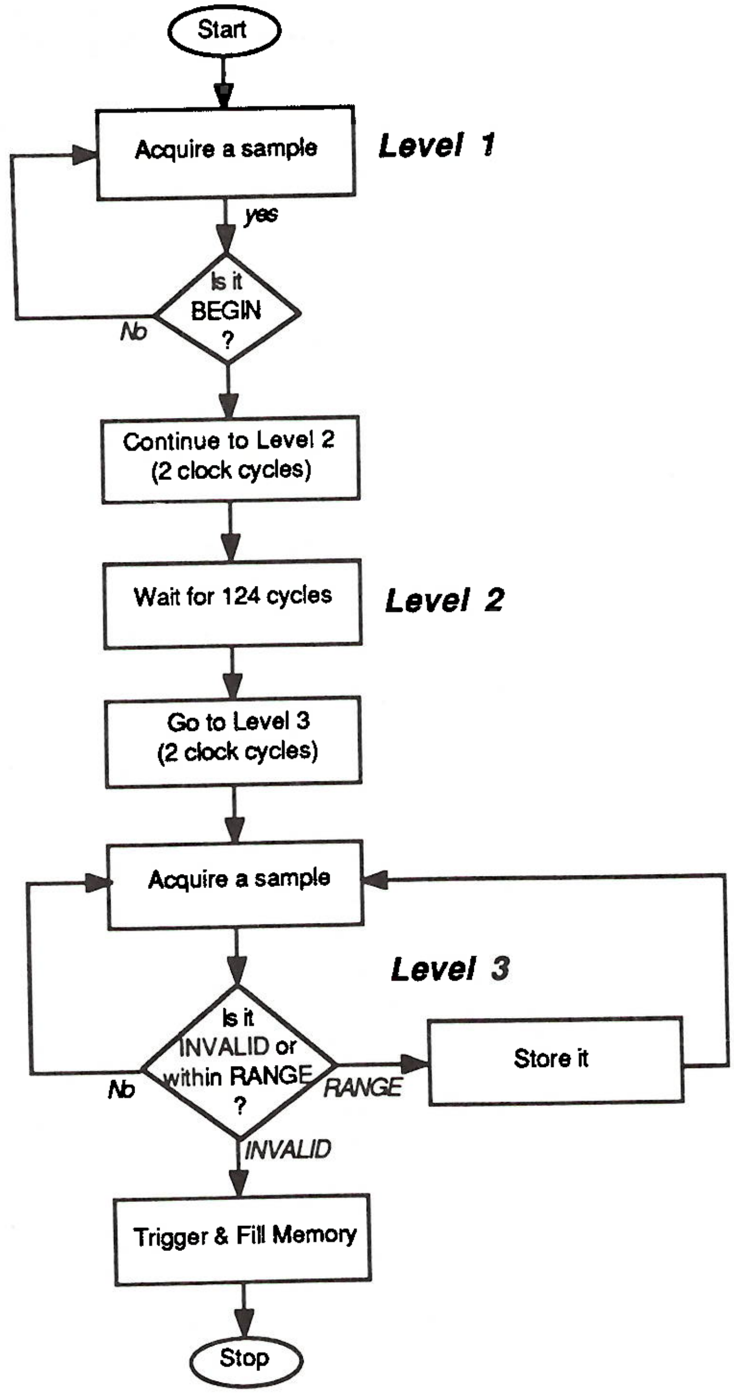

Figure 2-63. Flow chart shows the trigger specified in Figure 2-62.

Place the cursor on Level 2 and press ENTER until it consists of an IF statement. Select Clock as the condition, NOP as the action, and GOTO 3 as the destination.

Set the count to 124. We want to "throw away" the data that occurs during the first 128 clock cycles after BEGIN; however, we know the 1230 will lose two clock cycles going from Level 1 to Level 2 and another two cycles going from Level 2 to Level 3. By subtracting these four cycles from the 128 we want to miss, we know that in order to ignore exactly 128 cycles, the count should be 124.

Place the cursor on Level 3 and press ENTER until it consists of an IF...ELSE STORE ONLY statement. For the IF part of the statement, select INVALID as the condition, TRIG as the action, and FILL as the destination.

As the ELSE STORE ONLY condition, select RANGE.

Run Control Menu — Select State in the Display field. Since we are not interested in storing any data prior to BEGIN, select Immediately in the Look for Trigger field (see Figure 2-64).

Position the trigger at location 1920. Since we will be manually halting the acquisition, no data will be acquired after the trigger. Therefore, in order to get as large a data sample as possible, we want to place the trigger near the end of memory.

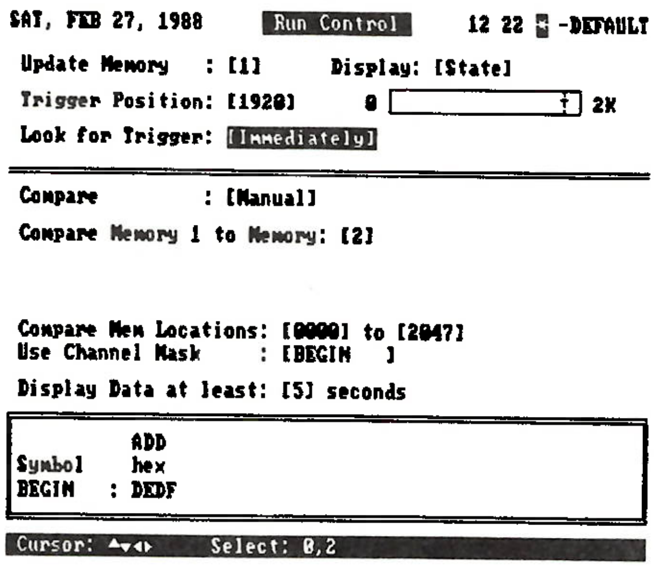

Figure 2-64. Run Control Menu for Example 13 shows that the 1230 will look for the trigger event immediately after START is pressed.

ACQUISITION AND DATA DISPLAY. Once you have finished making menu selections, press START to begin the acquisition. The 1230 immediately starts looking for BEGIN ($2FE0_{hex}$). Once it is recognized, control is transferred to to Level 2 where the 1230 essentially does nothing for 124 clock cycles. Then, control is transferred to Level 3 and the 1230 begins looking for either INVALID ($FFFF_{hex}$) or any value within the range 8100_{hex} to $81FF_{hex}$. If INVALID is occurs, the 1230 triggers and fills memory. Otherwise, every value falling within the range is stored.

After a few seconds have passed, press STOP to halt the acquisition. If the 1230 had stopped by itself, it would mean that the INVALID event had occurred.

Locate the trigger position. Every position after it is blank, the equivalent of no data. In this case, TRIG is the point at which you pressed STOP, thus halting the acquisition (see Figure 2-65).

Press F until the Search for field is in the menu bar. Select Acq Begin and press 1 to scroll data to the beginning of the acquisition. By scrolling through memory, you can see that only values between 8100 and 81FF have been stored. Highlighted state table locations show where acquired data matched one of the defined conditions. Since all the locations in this acquisition match the condition RANGE, they are all shown highlighted.

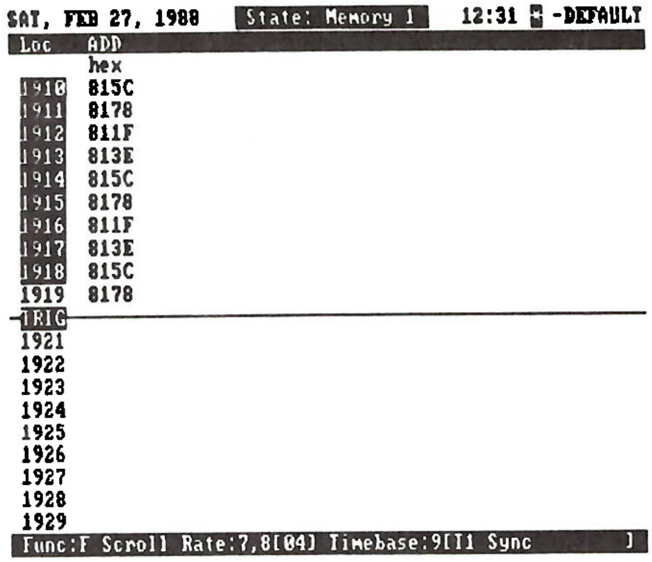

Figure 2-65. State table acquired in Example 13 shows that only values between 8100_{hex} and $81FF_{hex}$ have been stored.

Monitoring Program Flow

EXAMPLE FOURTEEN

OVERVIEW. So far, our examples have centered around triggering on a straightforward sequence of events. To analyze program flow, however, often requires a more complex trigger specification, one that can follow a sequence of events through various jumps, branches, and loops. To illustrate this, we will set up the 1230 to trace program flow through two interactive subroutines.

Suppose we want to acquire the data around a particular control signal such as an I/O READ. This signal occurs within an interrupt response routine (call it INT) that can be called from a number of different interrupt service routines (see Figure 2-66). However, we are only interested in cases where INT is called from one of two subroutines, SUB1 and SUB2. Figure 2-69 shows the trigger specification for this acquisition in flow chart form. As you can see, it contains a number of branches and loops, much like the program being monitored.

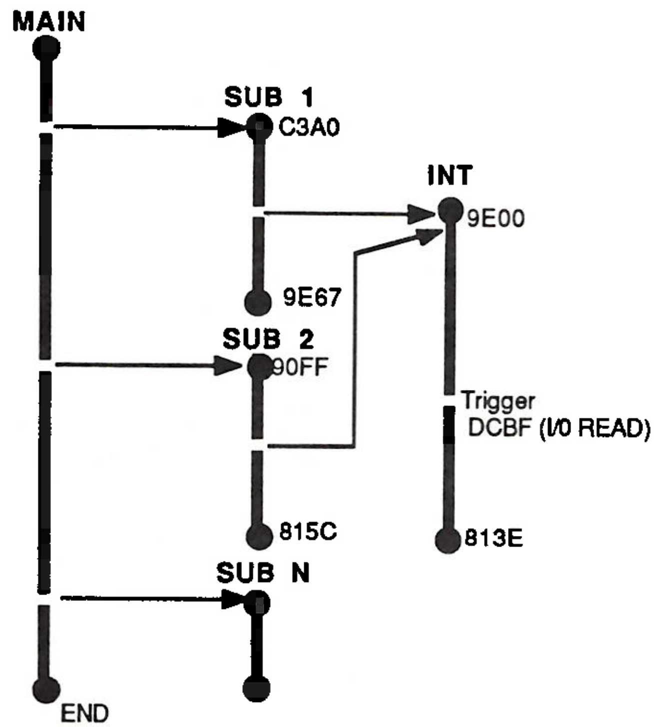

Figure 2-66. Hypothetical program being traced in Example 14.

With 14 levels available, the 1230 gives you a great deal of flexibility in setting up complex trigger specifications. However, keep in mind that the 1230 requires two clock cycles (or 80 ns, whichever is greater) to change trigger levels. Data samples occurring within that time are not recognized. For example, if the I/O READ occurs on the clock cycle following the one on which the beginning of INT was recognized, it would not be caught because the 1230 would be between trigger levels 3 and 4. Normally, choosing trigger events that occur far enough apart to be easily recognized does not create a problem.

PROBE CONNECTIONS. Use the same connections as were used in Example 13.

INSTRUMENT SETUP. Starting with the default setup, make the following menu changes.

Timebase Menu – Change the clock format to Sync as is shown in Figure 2-9.

Channel Grouping Menu – Change GPA to ADD (for Address) and leave the channels A15 through A00 assigned to it.

Conditions Menu – Press F until the Conditions Menu fills the screen. This will allow you to view all the conditions for this example at the same time (see Figure 2-67).

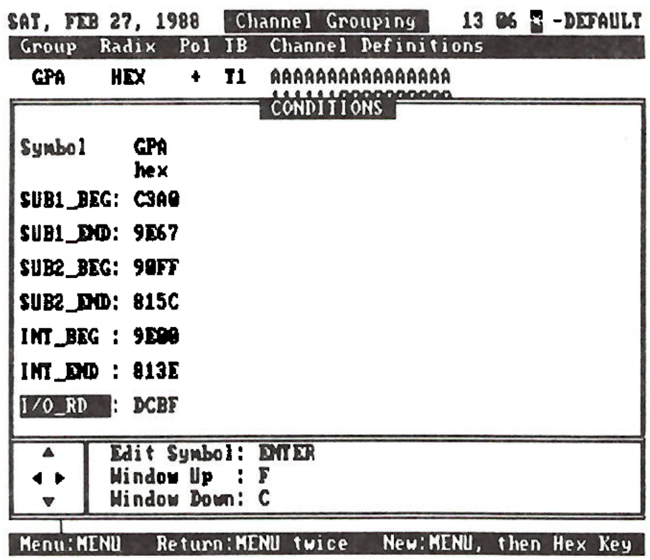

Figure 2-67. Conditions Menu for Example 14 defines the starting and ending values for three subroutines.

Change the symbol A to SUB1_BEG and define it as $C3A0_{hex}$.

Change the symbol B to SUB1_END and define it as $9E67_{hex}$.

Change the symbol C to SUB2_BEG and define it as $90FF_{hex}$.

Change the symbol D to SUB2_END and define it as $815C_{hex}$.

Change the symbol E to INT_BEG and define it as $9E00_{hex}$.

Change the symbol F to INT_END and define it as $813E_{hex}$.

Change the symbol G to I/O_RD and define it as $DCBF_{hex}$.

Trigger Spec Menu – Press 1 to enter Advanced Mode.

Place the cursor on Level 1 and press ENTER until the statement is of the IF...ELSE IF form (see Figures 6-68 and 2-69). For the IF part of the statement, select SUB1_BEG as the condition, NOP as the action, and CONTIN as the destination. For the ELSE IF part of the statement, select SUB2_BEG as the condition, NOP as the action, and GOTO 3 as the destination.

Conditions Menu – Press F until the Conditions Menu fills the screen. This will allow you to view all the conditions for this example at the same time (see Figure 2-68).

```
SAT, FEB 27, 1988        Trigger Spec          13:17   -DEFAULT
Level          Condition  Count          Action        Dest

 1     IF      [SUB1_BEG]*[0001] THEN [ NOP  ] & [CONTIN]
 ELSE IF       [SUB2_BEG]        THEN [ TRIG ] & [GOTO 3]

 2     IF      [SUB1_END]*[0001] THEN [ NOP  ] & [GOTO 1]
 ELSE IF       [INT_BEG ]        THEN [ NOP  ] & [GOTO 4]

 3     IF      [SUB2_END]*[0001] THEN [ NOP  ] & [GOTO 1]
 ELSE IF       [INT_BEG ]        THEN [ TRIG ] & [GOTO 4]

 4     IF      [I/O_RD  ]*[0001] THEN [ TRIG ] & [ FILL ]
 ELSE IF       [INT_END ]        THEN [ NOP  ] & [GOTO 1]

 5

DESTINATION:

GOTOnn - Go to the indicated level. Use GOTO with any
         action.

Cursor:▲▼◄► Select:0,2  Instruction:ENTER Basic:1
```

Figure 2-68. Trigger Spec Menu for Example 14 shows how program flow may be traced.

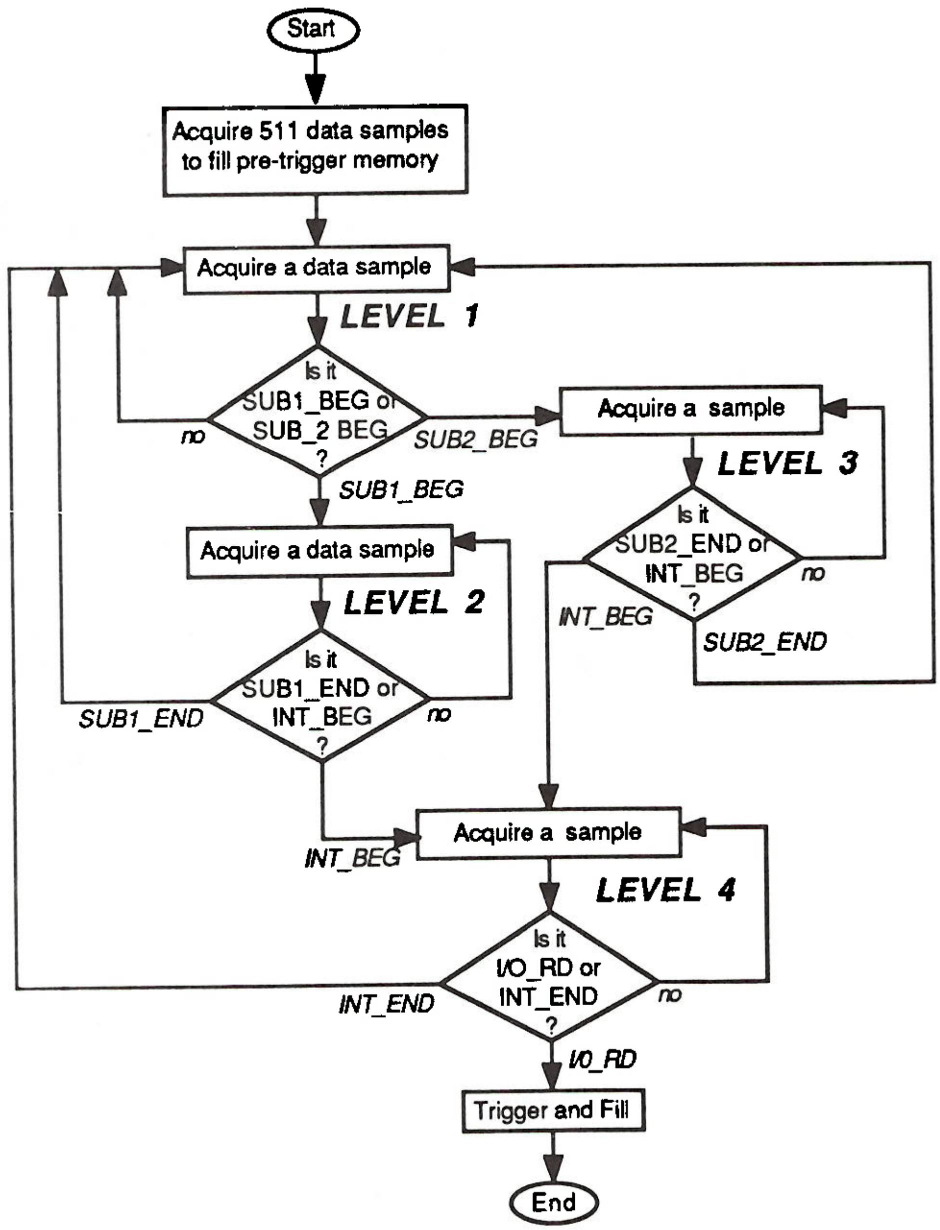

Figure 2-69. Flow chart shows the trigger specified in Figure 2-68.

Place the cursor on Level 2 and press ENTER until the statement is of the IF...ELSE IF form. For the IF part of the statement, select SUB1_END as the condition, NOP as the action, and GOTO 1 as the destination. For the ELSE IF part of the statement, select INT_BEG as the condition, NOP as the action, and GOTO 4 as the destination.

Place the cursor on Level 3 and press ENTER until the statement is of the IF...ELSE IF form. For the IF part of the statement, select SUB2_END as the condition, NOP as the action, and GOTO 1 as the destination. For the ELSE IF part of the statement, select INT_BEG as the condition, NOP as the action, and GOTO 4 as the destination.

Place the cursor on Level 4 and press ENTER until the statement is of the IF...ELSE IF form. For the IF part of the statement, select I/O_RD as the condition, TRIG as the action, and FILL as the destination. For the ELSE IF part of the statement, select INT_END as the condition, NOP as the action, and GOTO 1 as the destination.

Run Control Menu – Change the Display field to State.

ACQUISITION. Press START to begin the acquisition. The 1230 acquires enough data to fill pre-trigger memory, then starts looking for either of the two conditions in Level 1, $C3A0_{hex}$ or $90FF_{hex}$. Depending on which is recognized first, the 1230 branches either to Level 2 or to Level 3.

If the branch is to Level 2, the 1230 looks for either $9E67_{hex}$ or $9E00_{hex}$ to occur. If $9E67_{hex}$ occurs first, the 1230 jumps back to Level 1 and the trigger search starts over again. If $9E00_{hex}$ is recognized first, the 1230 branches to Level 4.

If the first branch is to Level 3, the 1230 looks for either $815C_{hex}$ or $9E00_{hex}$. If $815C_{hex}$ is recognized, the 1230 jumps back to Level 1 and the triggers search begins again. If $9E00_{hex}$ is recognized, the 1230 branches to Level 4.

Once control is at Level 4, the 1230 looks for either $813E_{hex}$ or $DCBF_{hex}$.

If $813E_{hex}$ is recognized, the 1230 jumps back to Level 1 and the search starts over. If DCBF is recognized, the 1230 triggers and fills memory. Data is processed and displayed in a state table.

DATA DISPLAY. In the State Menu, locate the trigger position and note that it contains $DCBF_{hex}$, the event defined as condition I/O_RD (see Figure 2-70).

Press F until the Search For field is in the menu bar. Press 2 until Acq Begin is selected. Then, press 1 to search for it. Data will scroll until the cursor is on the first memory location.

Press 2 until SUB1_BEG is in the Search for field. Then, press 1. Data will scroll until the cursor is on a location containing $C3A0_{hex}$.

Using the search function, locate in turn each of the defined conditions.

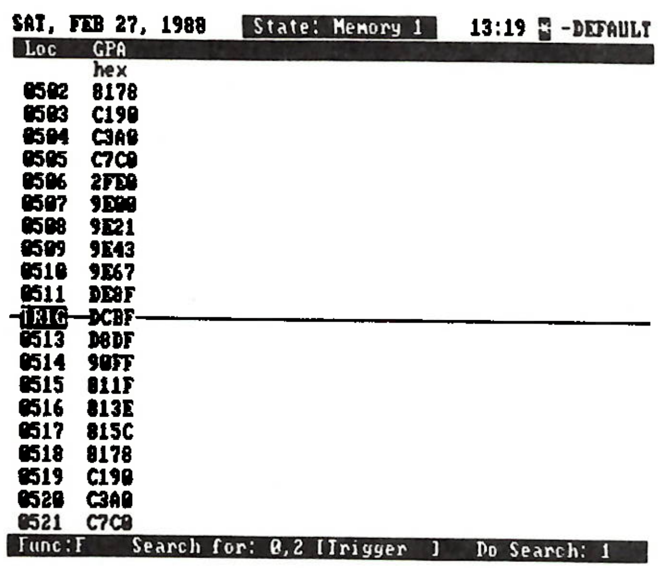

Figure 2-70. State Menu for Example 14.

SECTION THREE

EXAMPLES REQUIRING MORE THAN 16 CHANNELS

This section provides hands-on examples designed to familiarize you with the 1230 features that become available when one or more 1230E1 Expander Cards are installed. Each expander card supplies you with 16 more channels and an additional timebase. So, if you have the maximum of three 1230E1s installed, you have 64 channels and 4 timebases available.

The examples in this section are progressive, each building on the skills acquired in the previous examples. You should start at the beginning and work through the examples consecutively.

This section assumes you have read Section 1 of this workbook and have worked through the examples in Section 2.

NOTE

Instructions for installing 1230E1 cards in your 1230 Logic Analyzer are given in the 1230 Operator's Manual *(part number 070-6878-00).*

EXAMPLE ONE

Extending Events Across Probes

OVERVIEW. In this example, we will use a fully loaded 1230 (that is, one with three expander cards installed) to acquire data from 64 channels simultaneously. Three test cards will act as our SUT. We will group together channels from different probes to form two channel groups of 32 channels each. This will allow us to trigger on a data word that is 32 bits long.

Because of the test card's slow speed, we will only acquire data at 1 us. However, be aware that a fully configured 1230 allows you to see up to 64 channels with speeds at or below 40 ns (25 MHz), up to 32 channels at 20 ns (50 MHz), or up to 16 channels at 10 ns (100 MHz).

Before channels from different probes can be grouped together, the probes themselves must be linked so that they share the same timebase. This is so their acquisition clocks will be the same, thus ensuring that data from one probe is time correlated with data from the other. Any given channel group must be made up of channels from the same timebase. In other words, you cannot group channels from different probes together unless they have the same timebase.

The 1230 allows you to have up to four timebases, one for each probe. You may choose to have each probe acquiring data on different acquisition clocks. Or, you may link two or more probes together so that they acquire on the same clock.

After completing this example, you should know how to:

- change timebases
- link probes
- group channels from different probes together

REQUIRED EQUIPMENT. To do this example, you will need:

1 1230 Logic Analyzer with three 1230E1 Expander Cards installed

4 Probes (P6443)

8 lead sets (any combination of 174-1264-00, 174-1265-00, or 174-1266-00)

3 Test Circuits (671-0049-00)

PROBE CONNECTIONS. With the 1230 and all the test cards turned off, connect the four probes to the 1230. Then, connect the leads to the test cards as shown in Tables 3-1 through 3-4.

Table 3-1
PROBE A TO TEST CARD 1 CONNECTIONS

Input	Pin
D0	BIT23
D1	BIT22
D2	BIT21
D3	BIT20
D4	BIT19
D5	BIT18
D6	BIT17
D7	BIT16
GND	GND
D8	BIT15
D9	BIT14
D10	BIT13
D11	BIT12
D12	BIT11
D13	BIT10
D14	BIT9
D15	BIT8
GND	GND

Table 3-2
PROBE B TO TEST CARDS 1 & 2 CONNECTIONS

Input	Pin
D0	BIT7
D1	BIT6
D3	BIT5
D3	BIT4
D4	BIT3
D5	BIT2
D6	BIT1
D7	BIT0
GND	GND
D8	BIT23
D9	BIT22
D10	BIT21
D11	BIT20
D12	BIT19
D13	BIT18
D14	BIT17
D15	BIT16
GND	GND

Table 3-3
PROBE C TO TEST CARD 2 CONNECTIONS

Input	Pin
D0	BIT15
D1	BIT14
D2	BIT13
D3	BIT12
D4	BIT11
D5	BIT10
D6	BIT9
D7	BIT8
GND	GND
D8	BIT7
D9	BIT6
D10	BIT5
D11	BIT4
D12	BIT3
D13	BIT2
D14	BIT1
D15	BIT0
GND	GND

Table 3-4
PROBE D TO TEST CARD 3 CONNECTIONS

Input	Pin
D0	BIT23
D1	BIT22
D2	BIT21
D3	BIT20
D4	BIT19
D5	BIT18
D6	BIT17
D7	BIT16
GND	GND
D8	BIT15
D9	BIT14
D10	BIT13
D11	BIT12
D12	BIT11
D13	BIT10
D14	BIT9
D15	BIT8
GND	GND

After all the connections have been made, power up the 1230. Then, turn on all three test cards.

INSTRUMENT SETUP. Start with the default setup and make the following menu changes.

Timebase Menu – Press D until Probes A and B are linked in Timebase 1 and Probes C and D are linked in Timebase 2 (see Figure 2-71). As you exit this menu, you will be asked to confirm that you want to change links. Press ENTER to confirm the change.

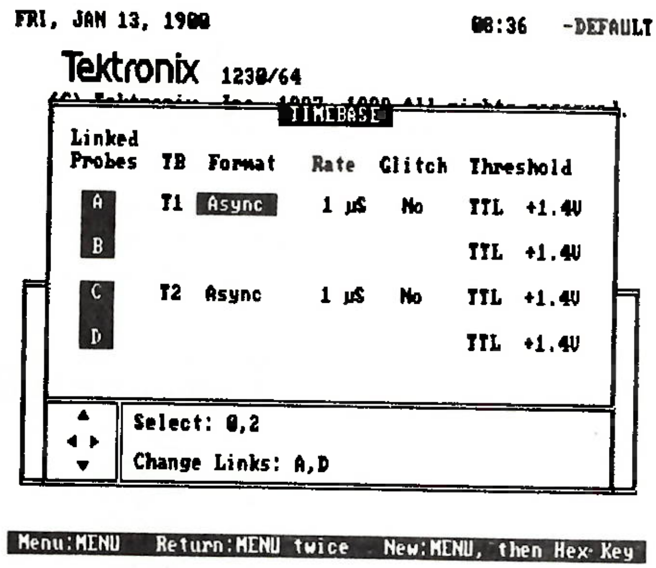

Figure 3-1. Timebase Menu shows Probes A and B and Probes C and D linked together.

Channel Grouping Menu – Change GPA to A&B and assign it all channels from Probes A and B. Remember, you must delete a channel from the group it is in before adding it to another group. In other words, you will have to delete all the channels from GPB before you can add them to A&B.

Change GPB to C&D and assign it all channels from Probes C and D (see Figure 3-2).

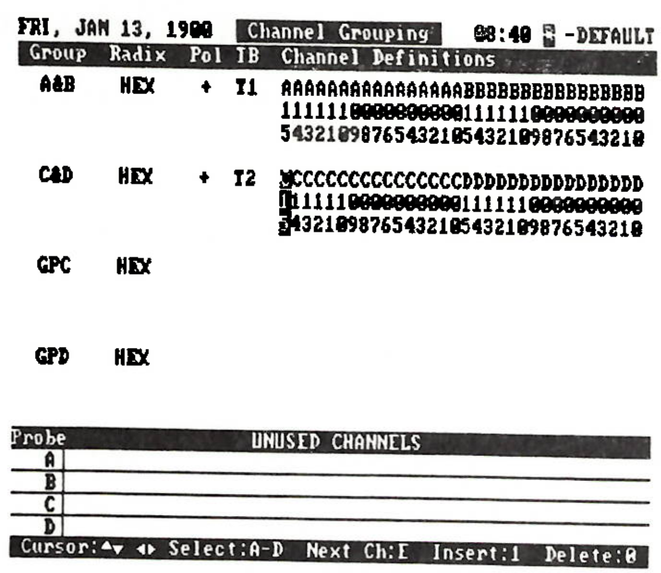

Figure 3-2 Channel Grouping Menu for Example 1 shows two channel groups, each with 32 channels assigned to it.

Run Control Menu – Change the Display field to State. When dealing with a large number of channels, it is usually easier to view data in state table format. It is difficult to sort through the waveforms of so many channels in timing diagram format.

Leave the Conditions and Trigger Spec Menus as they are. This will cause the 1230 to trigger on anything. The reason we want to do this is that we have no way of knowing where in time the signals on the tests cards are in relation to each other.

ACQUISITION AND DATA DISPLAY. Press START to begin the acquisition. The 1230 acquires enough data to fill pre-trigger memory, then triggers. Data is processed and displayed in a state table.

Notice that data is present only for channel group A&B. This is because only data from the same timebase can be viewed at one time. If data from multiple timebases were shown together, it would be meaningless because you would have no idea when the events occurred in relation to each other.

To switch timebases so that data from C&D is displayed, press 9. If you can't remember 9, just remember that pressing F will change the menu bar that lists key functions in this menu. The menu bar will also identify which timebase's data is being displayed (see Figure 3-3).

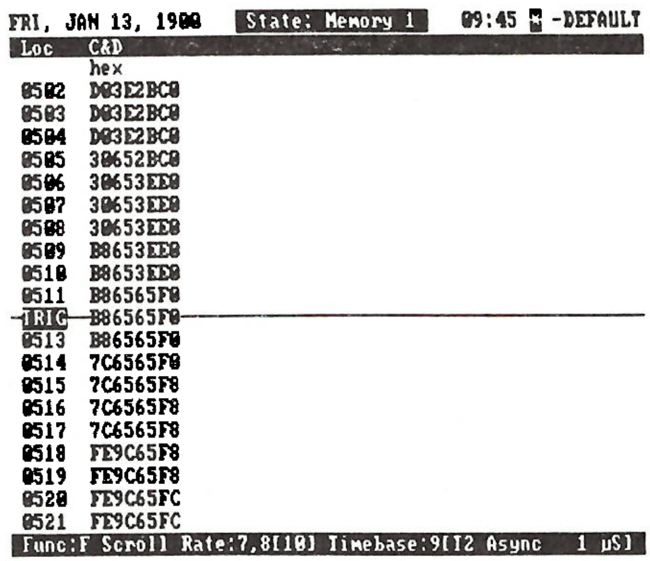

Figure 3-3. State Menu shows Timebase 1 acquired data.

EXAMPLE TWO

Acquiring Data with Two Timebases

In this example, we will acquire data on two timebases at the same time. One timebase will be asynchronous, the other synchronous. Acquiring two types of data like this is often useful when you are trying to integrate hardware and software. For example, suppose you had a microprocessor-based system. You could simultaneously monitor asynchronous control signals and synchronous bus activity.

After completing this example, you should know how to:

- simultaneously acquire synchronously and asynchronously
- send a trigger signal to another device

REQUIRED EQUIPMENT. This example requires you to have:

1 1230 Logic Analyzer with one 1230E1 Card installed

2 Probes (P6443)

4 lead sets (any combination of 174-1264-00, 174-1265-00, or 174-1266-00)

1 Test Circuit (671-0049-00)

PROBE CONNECTIONS. With the 1230 and all the test cards turned off, connect the two probes to the 1230. Then, connect the leads to the test cards as shown in Tables 3-5 and 3-6.

Table 3-5
PROBE A TO
TEST CARD CONNECTIONS

Input	Pin
D0	BIT23
D1	BIT22
D2	BIT21
D3	BIT20
D4	BIT19
D5	BIT18
D6	BIT17
D7	BIT16
GND	GND
D8	BIT7
D9	BIT6
D10	BIT5
D11	BIT4
D12	BIT3
D13	BIT2
D14	BIT1
D15	BIT0
GND	GND

Table 3-6
PROBE B TO
TEST CARD CONNECTIONS

Input	Pin
D0	BIT15
D1	BIT14
D3	BIT13
D3	BIT12
D4	BIT11
D5	BIT10
D6	BIT9
D7	BIT8
GND	GND
CLK HIGH	CLK1

After the connections have been made, power on the 1230. Then, turn on the test card.

INSTRUMENT SETUP. Start with the default setup. Then make the following menu changes.

Timebase Menu – Press D until A and B are each in their own timebase (see Figure 3-4). Set the format of A to Async and the format of B to Sync. To exit this menu, you will have to press ENTER to confirm the change in links.

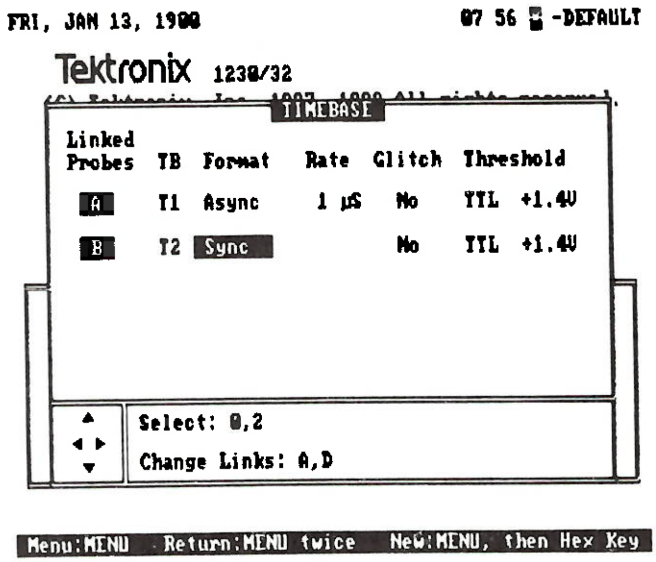

Figure 3-4. Timebase Menu shows two timebases: one Async, the other Sync.

Channel Grouping Menu – Change GPA to CTL and assign it channels A15 through A00 (see Figure 3-5).

Change GPB to BUS and assign it channels B07 through B00. Leave its radix HEX.

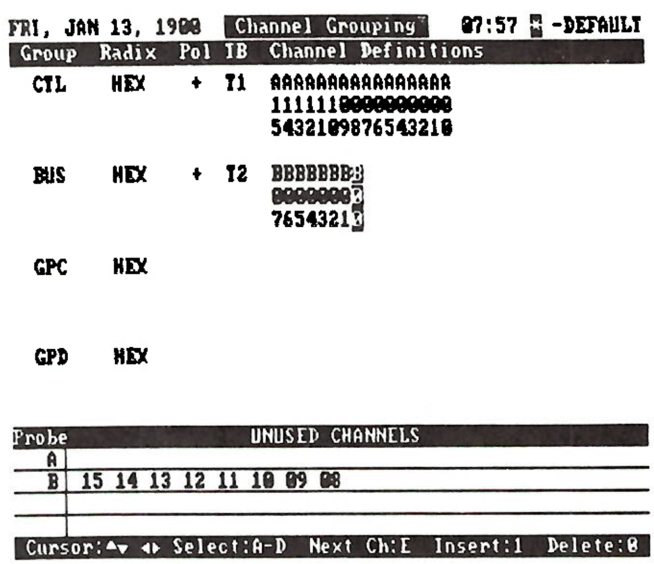

Figure 3-5. Channel Grouping Menu for Example 2.

Conditions Menu – For every symbol, leave the BUS group all don't cares. Change the symbol A to MREQ and define CTL as 907F*hex* (see Figure 3-6).

Change the symbol B to NMI and define CTL as 63FC*hex*.

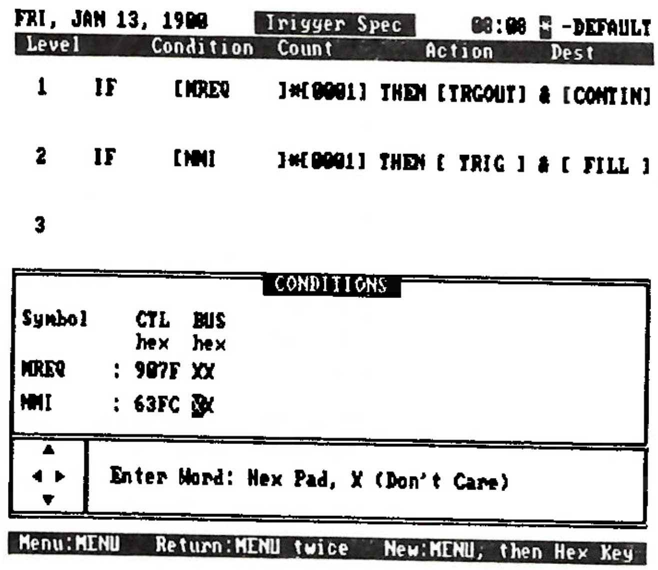

Figure 3-6. Trigger Spec and Conditions Menus for Example 2.

Trigger Spec Menu – In Level 1, select MREQ as the condition, TRGOUT as the action, and CONTIN as the destination (see Figure 3-6).

Place the cursor on Level 2 and press ENTER until it becomes an IF statement. Select NMI as the condition, TRIG as the action, and FILL as the destination.

Run Control Menu – Select State as the display type.

ACQUISITION AND DATA DISPLAY. After you have finished setting up the menus, press START to begin the acquisition. The 1230 acquires enough data to fill pre-trigger memory, then starts looking for MREQ. When it is recognized, the 1230 sends a signal out through the Trigger Out port on the rear-panel (presumably you have another device connected to it such as an oscilloscope or another logic analyzer). Control is then passed to Level 2 and the 1230 starts looking for NMI. When it is recognized, the 1230 triggers and fills memory. Data is displayed in a state table (see Figure 3-7). Data in the State Menu must all be acquired on one timebase. To view data acquired on the other timebase, press 9. This is one of the functions listed in the menu bar.

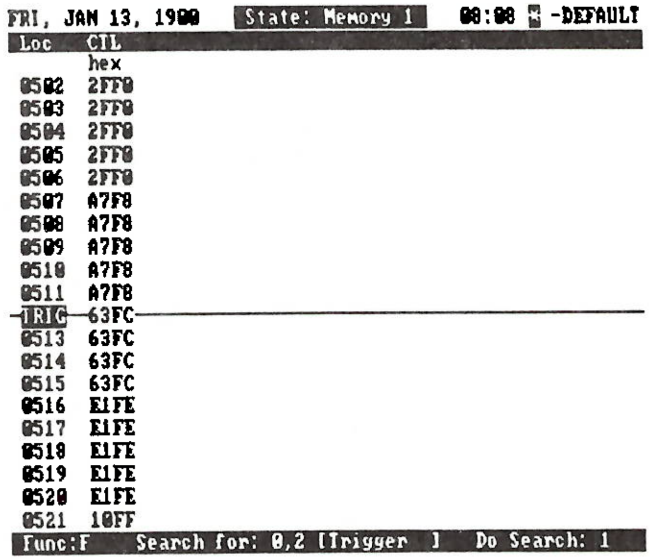

Figure 3-7. State Menu display data acquired in Example 2.

EXAMPLE THREE

Acquiring at High Speeds and Measuring Propagation Delays

OVERVIEW. In this example, we will measure the propagation delay of some of the components on the test card. Propagation delay is the time between the application of an input signal to a digital logic component or circuit to the resultant change of state at the output. For example, one of the delays we will measure is how long it takes an inverter to invert a signal.

We will set the 1230 up to trigger on a sequence of two events. The first event will be just prior to when the inputs to a NAND gate both go low. The second event is the circuit's resultant output. We will then measure some of the propagation delays that occurred between the two events.

After completing this example, you should know how to:

- group channels from different probes
- acquire data at 10 ns (100 MHz)
- use the reference cursor and data cursor to measure delays

REQUIRED EQUIPMENT. To do this example, you will need:

1 1230 Logic Analyzer with one 1230E1 Card installed

2 Probes (P6443)

4 lead sets (any combination of 174-1264-00, 174-1265-00, or 174-1266-00)

1 Test Circuit (671-0049-00)

PROBE CONNECTIONS. With the 1230 and the test circuit both powered down, connect the lead sets to the probes and to the SUT as shown in Table 3-7. Then, connect the probes to the 1230.

Table 3-7
PROBE TO TEST CARD CONNECTIONS

Input	Pin
D0	BIT15
D1	BIT1
D2	BIT0
D3	CLK2
D0	BIT9
D1	BIT12
D2	BIT14
D3	BIT13
GND	GND

After all the connections have been made, power up the 1230. Then, turn on the test card.

INSTRUMENT SETUP. Starting with the default setup, make the following menu changes.

Timebase Menu – Press D until Probes A and B are linked together (see Figure 3-8). Select Async as the clock format with a rate of 10 ns (100 MHz).

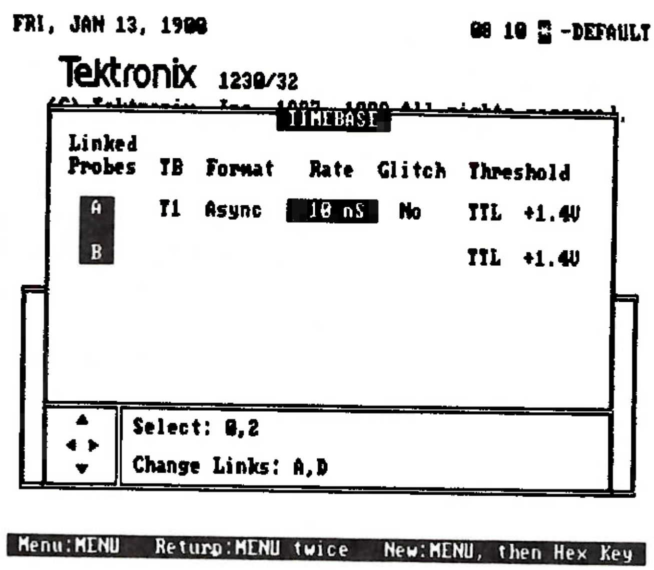

Figure 3-8. Timebase Menu shows a clock rate of 10 ns selected.

Channel Grouping Menu – Note that only the lower four bits from each probe are available at 10 ns (see Figure 3-9). Group all eight bits together in GPA. Make sure they are in the following order: A03, A02, A01, A00, B03, B02, B01, B00. Remember, you must delete the channels from GPB before you can add them to GPA.

Change the radix of GPA to BIN.

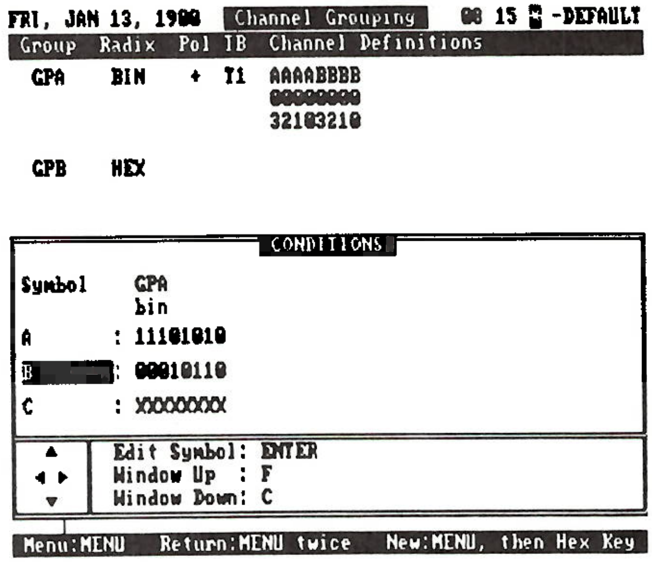

Figure 3-9. Channel Grouping and Conditions Menus for Example 3.

Conditions Menu – Define the symbol A as 11101010_{bin} and the symbol B as 00010110_{bin} (see Figure 3-9).

Trigger Spec – In Level 1, select A as the condition, NOP as the action, and CONTIN as the destination (see Figure 3-10).

Place the cursor on Level 2 and press ENTER until it becomes an IF statement. Select B as the condition, TRIG as the action, and FILL as the destination.

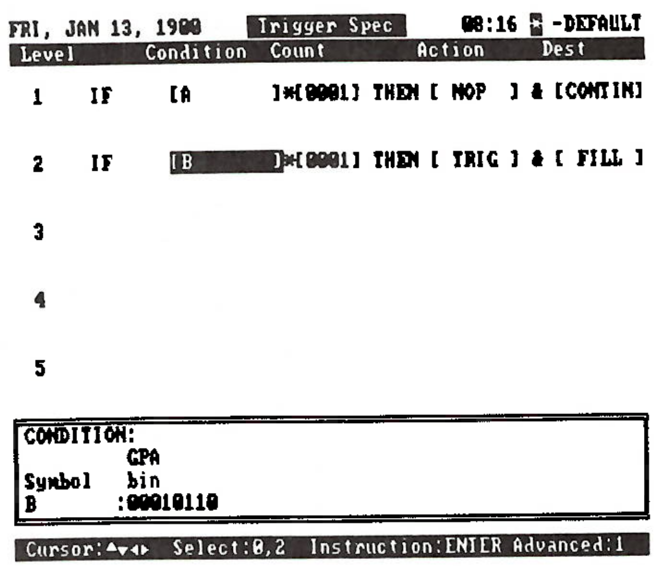

Figure 3-10. Trigger Spec Menu for Example 3.

ACQUISITION AND DATA DISPLAY. Press START to begin. The 1230 acquires enough data to fill pre-trigger memory, then starts looking for condition A. When it is recognized, control is transferred to Level 2 and the 1230 starts looking for condition B. When B is recognized, the 1230 triggers and fills memory. Data is processed and displayed in a timing diagram.

To make the timing diagram easier to read, change the names of the traces to match the test card bits. To change trace labels, do the following (see Figure 3-11):

1. Press E. The menu bar shows the edit functions available.
2. Use the up and down arrow keys to move the cursor to the label you want to change.
3. Press E to enter editor mode.
4. Use the up and down arrow keys to scroll characters through each position in the trace label field.
5. Press ENTER to exit editor mode when you have finished changing the label. Move the cursor to the other traces you want to rename and follow steps 3 and 4 again. Repeat this until you have changed all the trace names as follows:

   GPA07 to CLK2
   GPA06 to BIT0
   GPA05 to BIT1
   GPA04 to BIT15
   GPA03 to BIT13
   GPA02 to BIT14
   GPA01 to BIT12
   GPA00 to BIT9

6. When you have finished editing all traces, press ENTER.

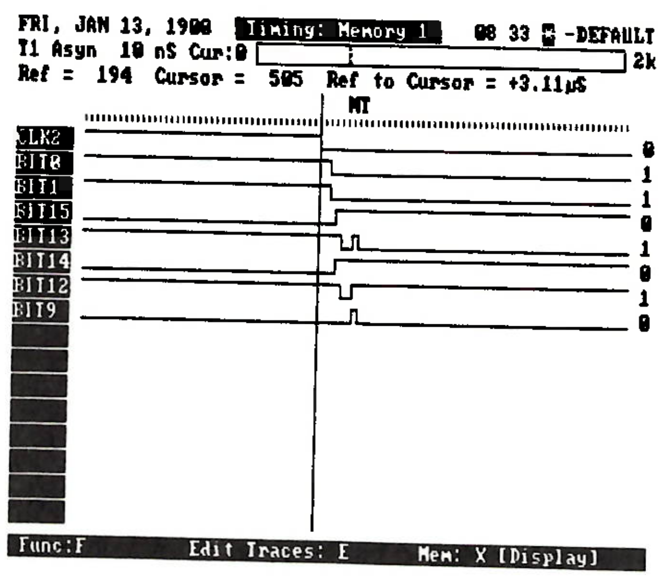

Figure 3-11. Timing Menu shows traces renamed.

To understand what you're seeing in the timing diagram, refer to the test circuit schematic in Figure A-2 on the pull-out page. Make sure the resolution of the timing diagram is 96 by pressing F until the menu bar at the bottom of the screen shows the resolution. If it is not 96, press 4 or 5 until 96 is selected.

Place the cursor on the trigger position, if it is not already there.

Channel trace CLK2 (GPA07) is the test card's clock. Move the cursor to the point where it goes low just prior to the trigger location (see Figure 3-11). Press ENTER to set this location as the cursor reference point. The Ref to Cursor field above the traces will be 0.

Move the cursor right to the point where BIT0 (GPA06) goes low. BIT1 (GP05) should also go low at this position. These channels are the inputs to the NAND gate U2A. The time shown in the Ref to Cursor field is the delay between when the clock went low and when the inputs went low.

When BIT0 and BIT1 (GPA06 and GPA05) go low, the NAND gate outputs a high. To measure the propagation delay through the gate, press ENTER to zero the reference at the point where the inputs go low. Then move the cursor right to the point where GPA04 (bit 15, the output from the gate) goes high. The reference field shows the delay.

How much propagation delay there should be is a function of the battery voltage. To find out exactly what the specification is, you need a high-speed CMOS data book. Measure the battery voltage and look up the component's propagation delay at that voltage in the data book.

Move the cursor to the position where BIT12 (GPA01) goes low. Press ENTER to zero the reference at this point. Move the cursor right to where BIT9 (GPA00) goes high. The reference is the propagation delay through the inverter U3 on bit 9.

If you want to, there are a few more delays you can measure in this data sample. You can measure the total time from when bits 0 and 1 went low to the change in bit 9. If you measure the delay between bits 15 and 13, you will know the duration of the pulse we used as a glitch in Example 11.

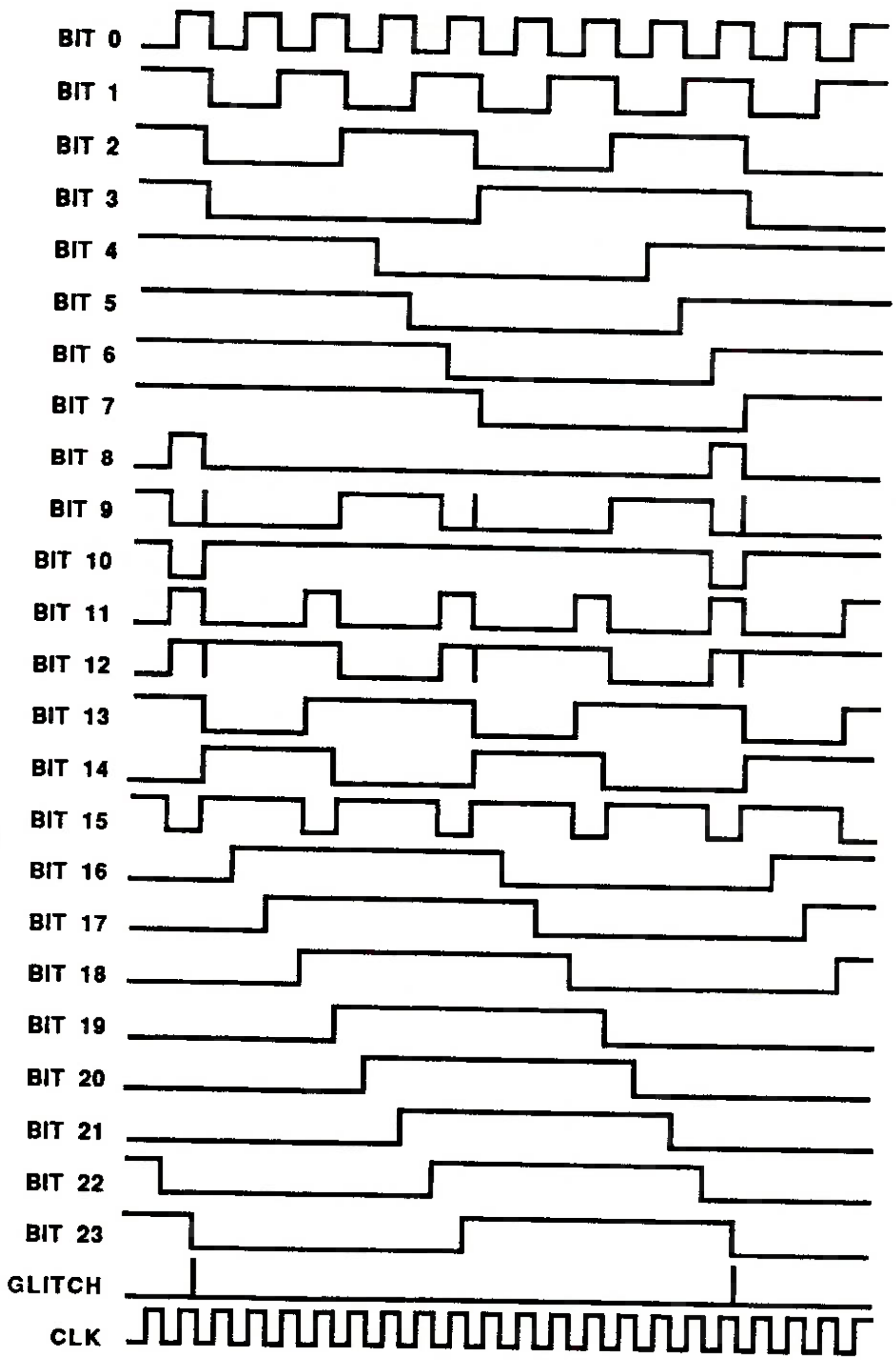

Figure A-1. Timing Diagram for the Test Card.

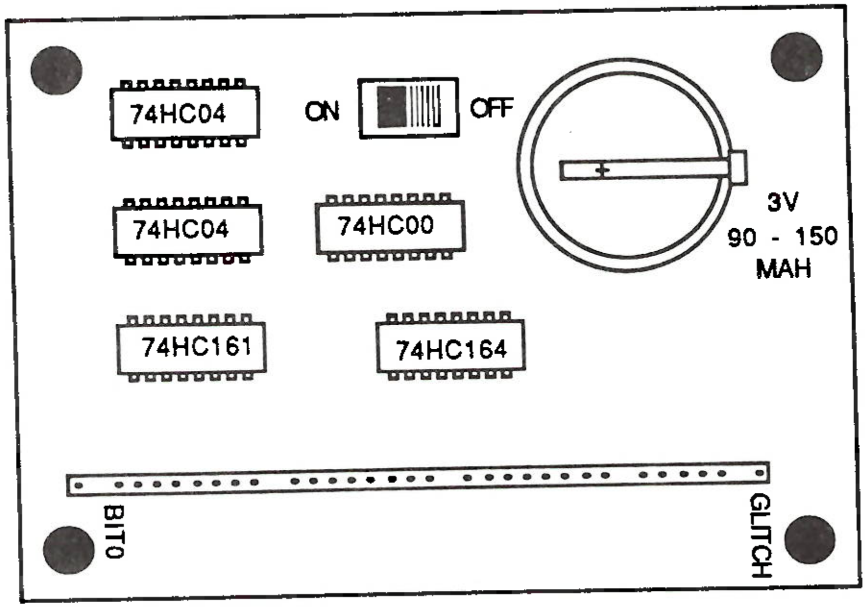

Figure A-2. Test Card Schematic.

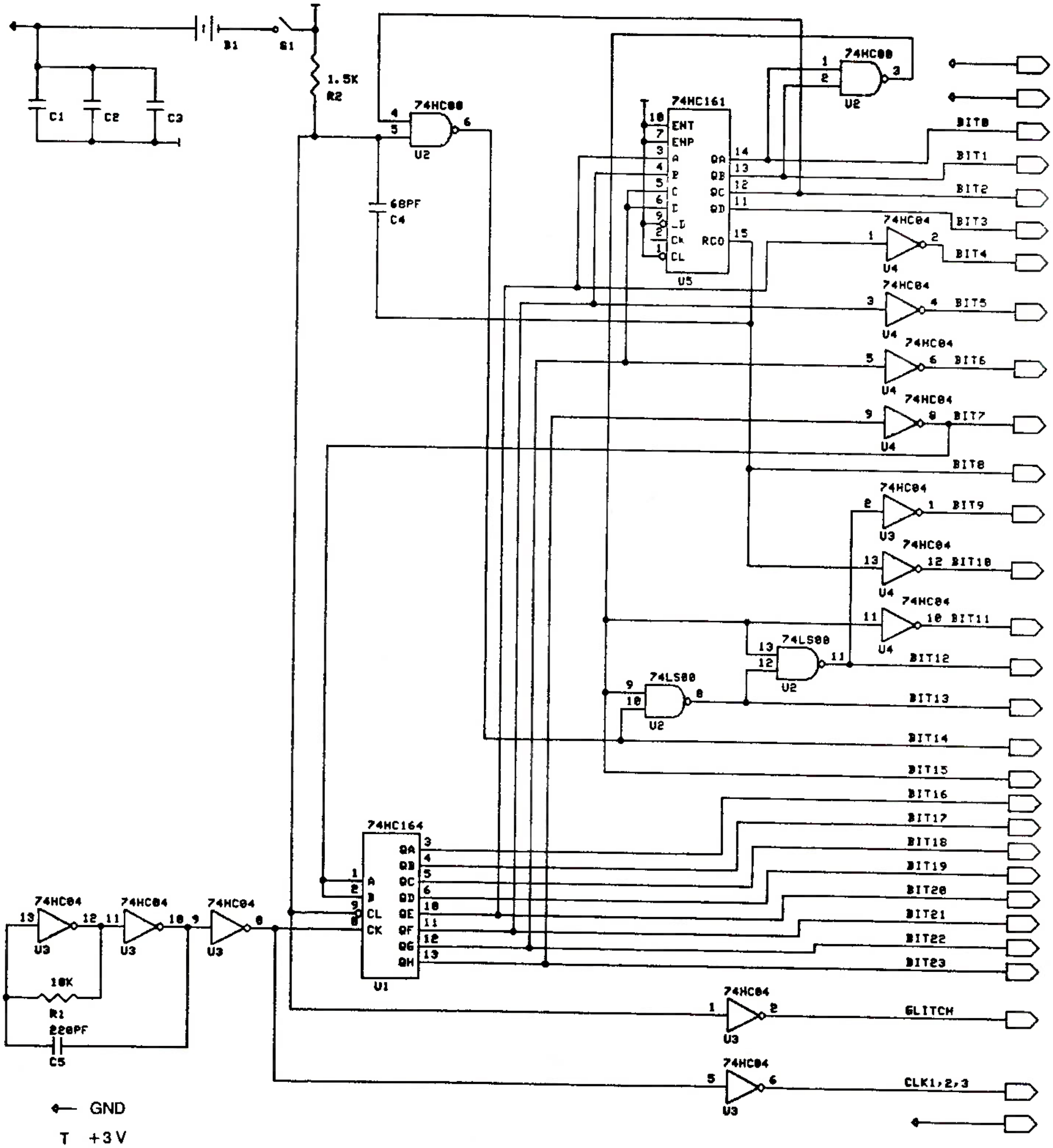

Figure A-3. Test Card Circuit Diagram.